Reed Electronics Group

EDN

VOICE OF THE ENGINEER

JAN 5

Issue 1/2006

www.edn.com



DAT stirs piracy fears, loses out to plastic discs Pg 94

802.11n progress: consensus building or end run? Pg 14

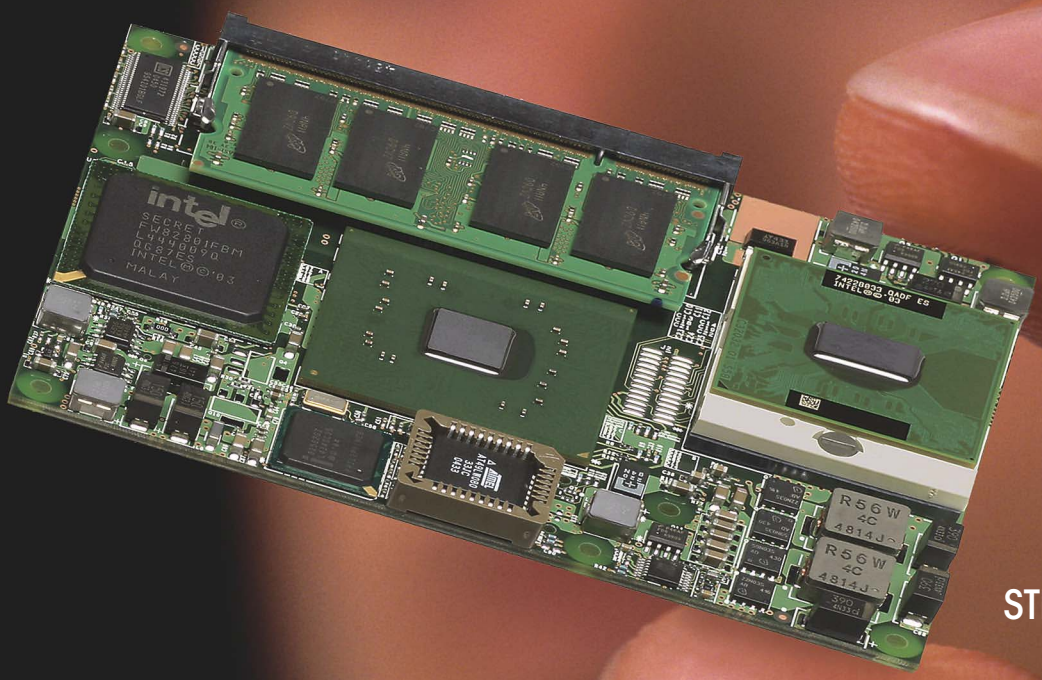
Howard Johnson: Half-measures Pg 36

Tales from the Cube: Valuing uncertainty Pg 38

Design Ideas Pg 79

Serial streams shrink embedded-system designs

Page 52



CHOOSING HIGH-SPEED AMPLIFIERS FOR NOISE-SENSITIVE APPLICATIONS

Page 41

DESIGN CHALLENGES STEER AUTOMOTIVE ELECTRONICS

Page 61

DESIGNING RF-IC FILTERS USING AN AUTOMATED CIRCUIT AND LAYOUT SYNTHESIS

Page 71

14-Bit, 190 MSPS ADC

Speed and Performance

Device	Resolution	Speed	SNR	SFDR
ADS5546	14 Bits	190 MSPS	73.2 dBFS at 70 MHz IF	84 dBc at 70 MHz IF
ADS5545	14 Bits	170 MSPS	73.5 dBFS at 70 MHz IF	85 dBc at 70 MHz IF
ADS5444	13 Bits	250 MSPS	68.6 dBFS at 230 MHz IF	78 dBc at 230 MHz IF
ADS5440	13 Bits	210 MSPS	69.1 dBFS at 230 MHz IF	79 dBc at 230 MHz IF

The new high-performance, low-power ADS5546 ADC from Texas Instruments features 1.1W total power consumption in an ultra-small, 7mm x 7mm QFN package. It supports both high SNR and SFDR at high input frequencies and offers unprecedented interface flexibility with user-selectable CMOS or DDR LVDS outputs. The ADS5546 is ideal for demanding applications such as wireless communications, video, imaging, instrumentation, test and measurement.

High Performance. Analog. Texas Instruments.

For datasheets, samples and evaluation modules, visit
www.ti.com/ads5546



Technology for Innovators and the red/black banner are trademarks of Texas Instruments. 1260AD. © 2005 TI

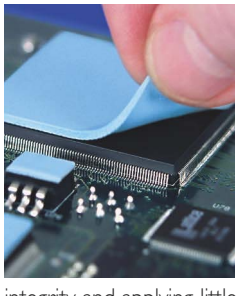
Technology for Innovators™

Texas Instruments


ACROSS THE BOARD
SELECTION
Access to over 540,000 part numbers from more than
320 quality, name-brand manufacturers!
SAME-DAY SHIPMENT
On Orders Entered By:
8:00
PM Central
NEXT-DAY DELIVERY
Digi-Key
CORPORATION
1.800.344.4539 · www.digikey.com

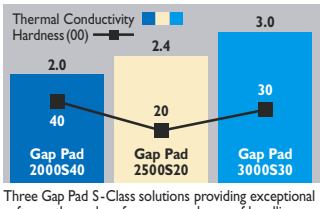
AN ORIGINAL NEVER CRUMBLES.

Unlike Imitations, Bergquist's Gap Pad® S-Class Stays Soft While Providing Superior Thermal Performance.



Gap Pad S-Class stays soft. It doesn't flake, tear or crumble for easy application.

Say good-bye to crumbling, oily gap fillers for good. Bergquist's super-soft Gap Pad S-Class thermally conductive gap filling materials conform to demanding contours while maintaining structural integrity and applying little or no stress to fragile components. In addition, S-Class' natural inherent tack provides more stable release characteristics, making it cleaner and easier to handle in the application assembly process.



Three Gap Pad S-Class solutions providing exceptional softness, thermal performance and ease of handling.

Maximize thermal performance with Gap Pad S-Class.

S-Class materials provide high thermal conductivity for exceptionally low thermal resistance at ultra-low mounting pressures – our best thermal performance material yet. The elastic nature of the material also provides excellent interfacing and wet-out performance. And because of its natural inherent tack, S-Class eliminates the need for additional adhesive layers that can increase interfacial resistance and inhibit thermal performance.

FREE sample kit and S-Cap.

Visit our web site or call today to qualify for your FREE S-Class sample kit and S-Cap.



FREE sample kit and S-Cap

Call **1.800.347.4572** or visit **www.bergquistcompany.com/ease**

THE BERGQUIST COMPANY

18930 West 78th Street • Chanhassen, MN 55317 • A ISO9001:2000 registered facility
(800) 347-4572 • Phone (952) 835-2322 • Fax (952) 835-0430 • www.bergquistcompany.com

Thermal Products • Membrane Switches • Touch Screens • Electronics • Labels and Graphic Overlays

Intersil Switching Regulators

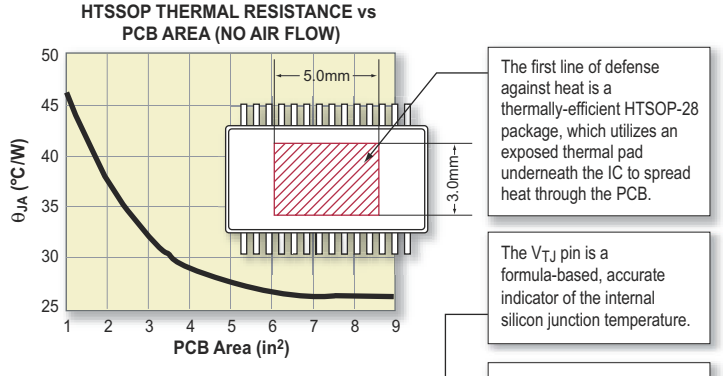
Intersil High Performance Analog

The Smart Dogs Just Know How To Keep Their Cool



Intersil's new high current Integrated FET Regulators have some new tricks to teach the old dogs, including the industry's only true Thermal Protection with auto shut down at 135°C.

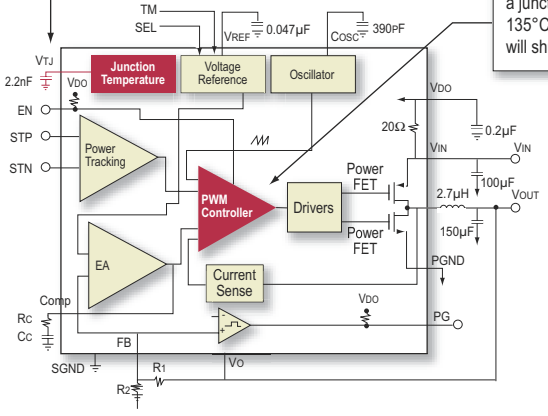
Intersil's EL7554 and EL7566 DC-DC buck regulators with internal CMOS power FETs operate from 3V-to-6V input voltage and are capable of up to 96% efficiency. But what's really cool about these devices is ground breaking features like built-in Thermal Protection and Voltage Margining for actual in-circuit performance validation.



The first line of defense against heat is a thermally-efficient HTSOP-28 package, which utilizes an exposed thermal pad underneath the IC to spread heat through the PCB.

The V_{TJ} pin is a formula-based, accurate indicator of the internal silicon junction temperature.

If all else fails and the temperature sensor indicates a junction temperature above 135°C, the PWM Regulator will shut down.



Key Features:

- 4A (EL7554) and 6A (EL7566) continuous output current
- Up to 96% efficiency
- Built-in 5% voltage margining
- 3V-to-6V input voltage
- 0.58 in² (EL7554) and 0.72 in² (EL7566) footprint with components on one side of PCB
- Adjustable switching frequency to 1MHz

For more information and samples, go to **www.intersil.com/edn**

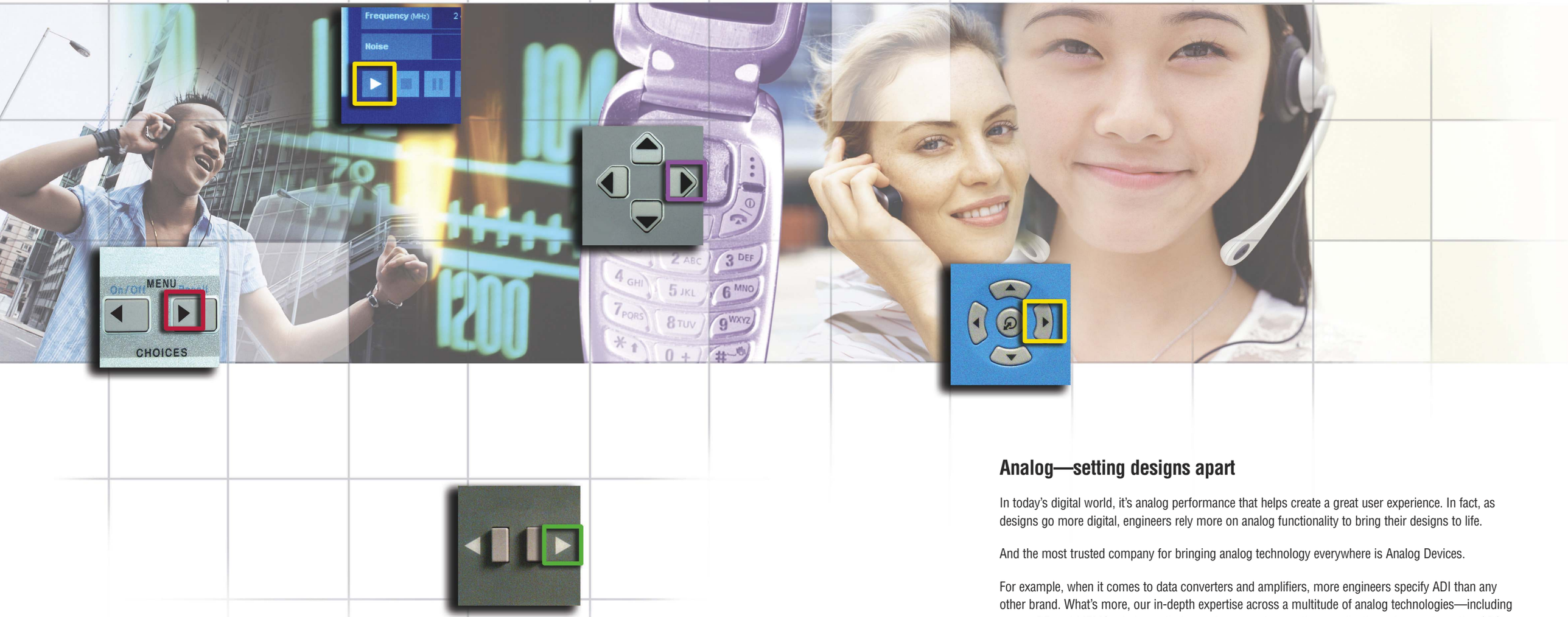
Easy-to-use simulation tool also available. Modify switching frequency, voltage ripple, ambient termperature and view schematics waveforms, efficiency graphs and complete BOM with Gerber layout.

Intersil – Switching Regulators for precise power delivery.

©2005 Intersil Americas Inc. All rights reserved. The following are trademarks or services marks owned by Intersil Corporation or one of its subsidiaries, and may be registered in the USA and/or other countries: Intersil (and design) and i (and design).

intersil®
HIGH PERFORMANCE ANALOG

Amplifiers to ADCs, Shanghai to San Jose, analog is everywhere.



Analog—setting designs apart

In today's digital world, it's analog performance that helps create a great user experience. In fact, as designs go more digital, engineers rely more on analog functionality to bring their designs to life.

And the most trusted company for bringing analog technology everywhere is Analog Devices.

For example, when it comes to data converters and amplifiers, more engineers specify ADI than any other brand. What's more, our in-depth expertise across a multitude of analog technologies—including power, RF, and MEMS—helps optimize performance in countless applications, from automotive GPS and advanced TV to MP3 and medical imaging equipment.

For more than 40 years, ADI has been delivering innovative, reliable analog solutions that meet the most demanding performance and budget requirements.

Celebrate the analog world. Order your free "analog is everywhere" poster.

analog is everywhere.™

www.analog.com/everywhere

ANALOG DEVICES



PRECISE POWER MANAGEMENT.

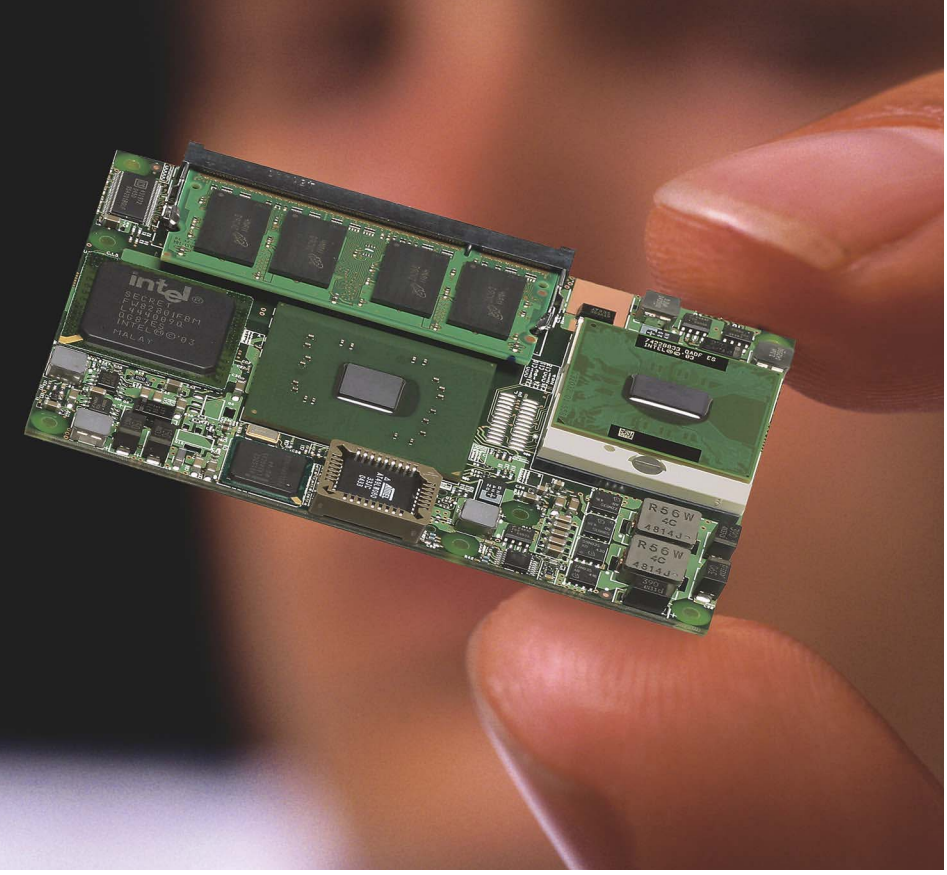
IT TAKES THE PAIN OUT OF DESIGNING LOW-POWER ICs

Increasing feature, function and processing requirements make it harder than ever to manage power consumption in personal electronics, wireless and handheld devices. A design system that concurrently analyzes and optimizes your IC for power, timing, area, signal integrity and yield is what you need. And that's what Magma provides. Blast Power™ and Blast Rail™ NX facilitate significant power reductions throughout the flow, enabling you to complete low-power chips faster. Your design will blow the socks off your competitors' chips but won't blow your power budget, or your schedule.

For more on how Magma lets you get the most out of your chips with just the right amount of power, visit **www.magma-da.com/4LowPower**. Find out why the world's top chip companies rely on Magma software to design their most critical ICs.

MAGMA®

© 2005 Magma Design Automation, Inc. All rights reserved. Magma and the Magma logo are registered trademarks and Blast Power and Blast Rail are trademarks of Magma Design Automation, Inc.



EDN

contents

1.5.06

Choosing high-speed amplifiers for noise-sensitive applications

41 Voltage feedback, current feedback, bipolar, CMOS—all have advantages and drawbacks. Here's a road map for picking the best type for your application.

by Jeffrey Lies, Tamara Papalias, and Mike Wong, Intersil Corp

Designing RF-IC filters using an automated circuit and layout synthesis

71 RF-IC designers can automate tedious filter-design iterations by integrating design steps with an electromagnetic simulator.

by Changhua Wan and Jian-X Zheng, Zeland Software Inc

Serial streams shrink embedded-system designs

52 Mobile- and small-form-factor-product designers turn to fabric technology and off-the-shelf computer modules to beat the competition. *by Warren Webb, Technical Editor*

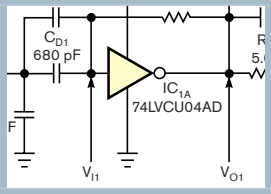
Design challenges steer automotive electronics

61 The automotive industry uses sophisticated mechanical design tools but could benefit from electronic system design automation.

by Michael Santarini, Senior Editor



DESIGNIDEAS



79 CMOS inverters convert RF to digital signal

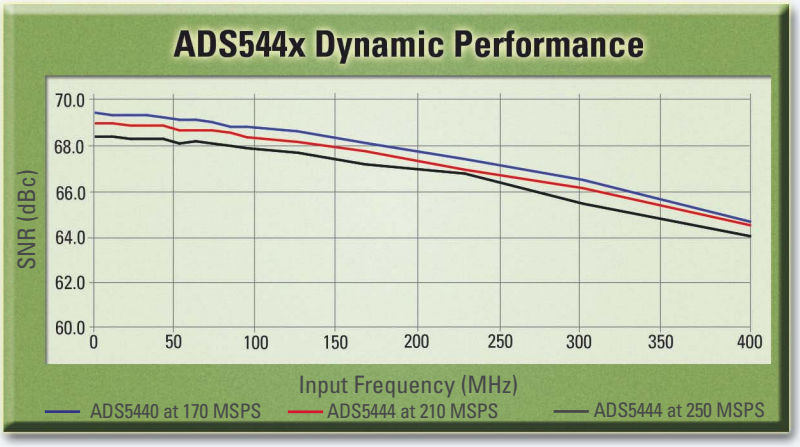
82 Instrumentation amplifier extends DSO

84 Virtual instrument determines magnetic core's B-H-loop characteristics

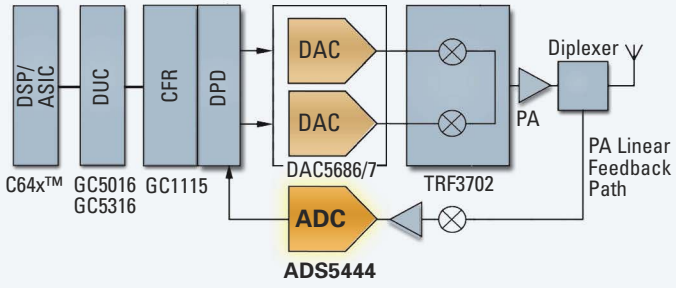
▶ Send your Design Ideas to EDNdesignideas@reedbusiness.com.

High Speed, Top Performance!

13-Bit, 250-MSPS ADC



Sample Application: Wideband, High IF DPD Feedback Receiver



The new **ADS5444** from Texas Instruments sets a new benchmark for high-speed ADCs, providing best-in-class performance at 250 MHz. Look to TI for a complete portfolio of high-speed ADCs, including the recently announced ADS5440 13-bit, 250 MSPS ADC.

Device	Resolution (Bits)	Speed (MSPS)	SNR (dBc)	SFDR (dBc)
ADS5444	13	250	68 at 230 MHz IF	75 at 230 MHz IF
ADS5440	13	210	68 at 230 MHz IF	79 at 230 MHz IF
ADS5500	14	125	69.5 at 100 MHz IF	82 at 100 MHz IF
ADS5424	14	105	74 at 50 MHz IF	93 at 50 MHz IF
ADS5541	14	105	71 at 100 MHz IF	86 at 100 MHz IF
ADS5423	14	80	74 at 50 MHz IF	94 at 50 MHz IF
ADS5520	12	125	68.7 at 100 MHz IF	82 at 100 MHz IF
ADS5521	12	105	69 at 100 MHz IF	86 at 100 MHz IF

▶ Applications

- Software-defined radio
- Base stations:
 - Wideband receiver
 - High IF receiver
 - PA linearization
- Instrumentation
- Test and Measurement

▶ Features

- 100 MHz IF: SNR = 68.7 dBc; SFDR = 73 dBc
- 230 MHz IF: SNR = 68 dBc; SFDR = 75 dBc
- Fully buffered analog inputs
- 2.2 Vpp differential input voltage
- 3.3 V LVDS compatible outputs
- TQFP-80 PowerPAD™ package
- Industrial temperature range –40°C to +85°C
- Price: $95 1k

New!

Amplifier and Data Converter Selection Guide, Datasheets, Samples, Evaluation Modules



www.ti.com/ads5444 ○ 800.477.8924, ext. 2695

Technology for Innovators™

Texas Instruments

PowerPAD, Technology for Innovators and the red/black banner are trademarks of Texas Instruments. 1171A0

© 2005 TI

contents 1.5.06

pulse



Dilbert 28

27 PMC card fits multimedia applications

27 SiGe power amp targets PHS handsets to WiFi

27 ADC blazes at 190M samples/sec but sips power

28 Scopes' array of features, performance, size, and price breaks new ground

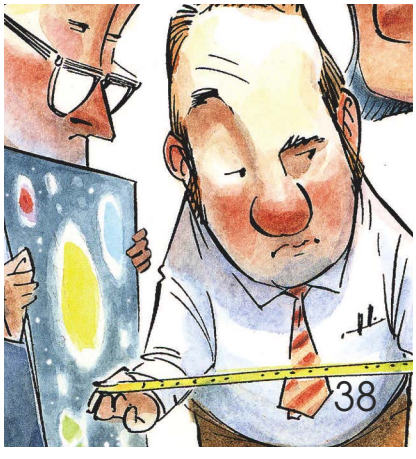
30 Platform simplifies video

30 GSM phone on chip targets handsets

32 **Research Update:** Physicists force six atoms to act like quantum "cats"; Carbon nanotubes suck heat from high-performance amps; Chip electrically controls the speed of light

34 **Global Designer:** EDA-tool pairing tackles ESL "model gap"; ADCs use less than 100 mW at 40 MHz and 14 bits







DEPARTMENTS & COLUMNS

14 **EDN.comment:** 802.11n progress: consensus building or end run?

36 **Signal Integrity:** Half-measures

38 **Tales from the Cube:** Valuing uncertainty

94 **Reality Check:** DAT stirs piracy fears, loses out to plastic discs

PRODUCT ROUNDUP

89 **Discrete Semiconductors:** BJT/MOSFET hybrids, power amplifiers, I/O expanders, ESD-protection devices, and more

91 **Integrated Circuits:** CMOS image sensors, audio power amplifier, and active-pixel design

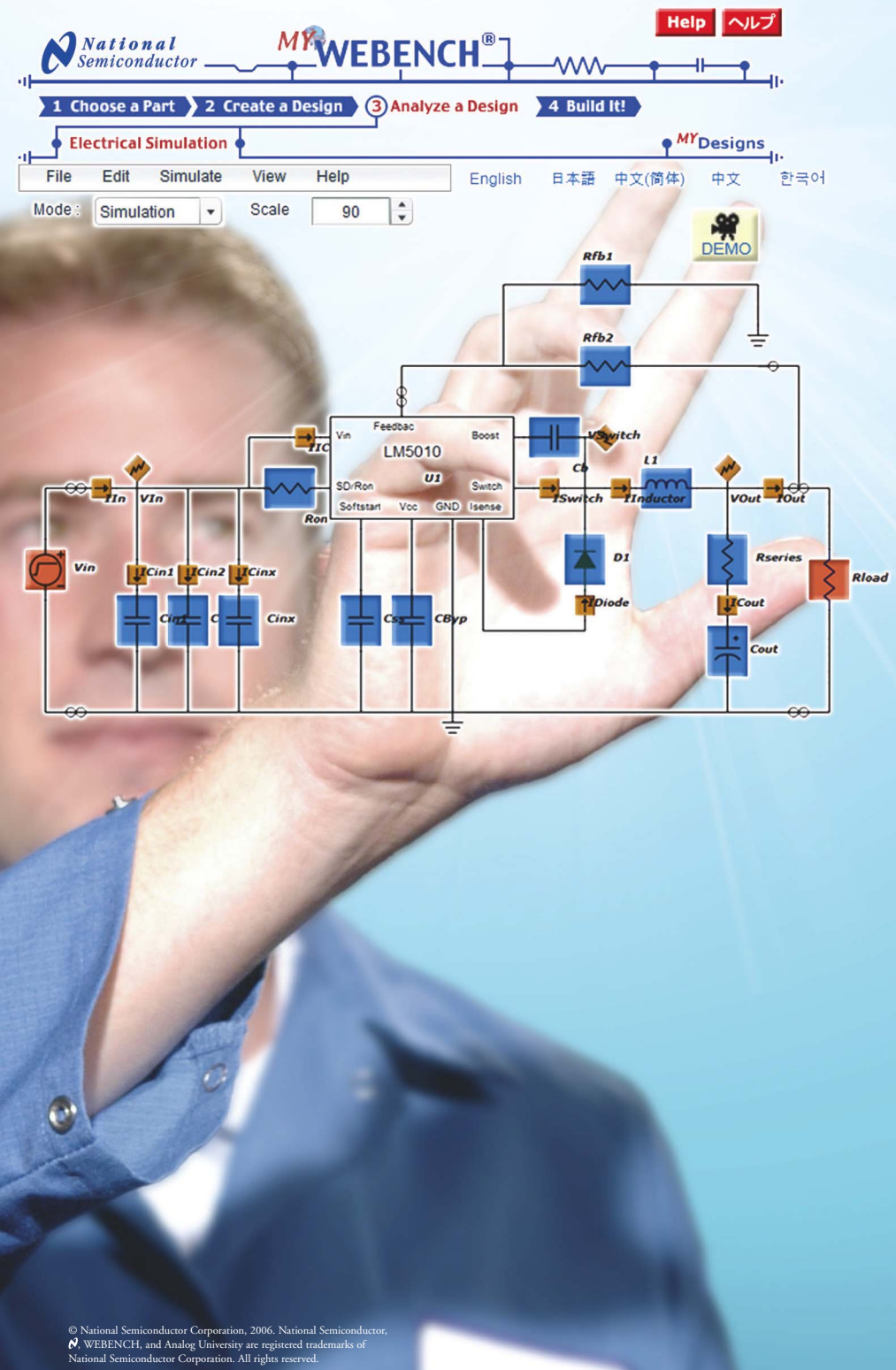
EDN® (ISSN#0012-7515), (GST#123397457, R.B.I. Intl Pub Mail #0280844) is published biweekly, 26 times per year, by Reed Business Information, 8878 Barrons Blvd, Highlands Ranch, CO 80129-2345. Reed Business Information, a division of Reed Elsevier Inc, is located at 360 Park Avenue South, New York, NY 10010. Tad Smith, Chief Executive Officer; Stephen Moylan, President, Boston Division. Periodicals postage paid at Littleton, CO 80126 and additional mailing offices. Circulation records are maintained at Reed Business Information, 8878 S Barrons Blvd, Highlands Ranch, CO 80129-2345. Telephone (303) 470-4445. POSTMASTER: Send address changes to EDN®, PO Box 7500, Highlands Ranch, CO 80163-7500.

EDN® copyright 2006 by Reed Elsevier Inc.

Rates for nonqualified subscriptions, including all issues: US, $149.90 one year; Canada, $205.90 one year, (includes 7% GST, GST#123397457); Mexico, $195.90 one year; air expedited, $361.90 one year. Except for special issues where price changes are indicated, single copies are available for $10 US and $15 foreign. Publications Mail Agreement No. 40685520. Return undeliverable Canadian addresses to: Deutsche Post, 4960-2 Walker Road, Windsor ON N9A 6J3. E-mail: subsmail@reedbusiness.com. Please address all subscription mail to EDN®, 8878 S Barrons Blvd, Highlands Ranch, CO 80129-2345. EDN® is a registered trademark of Reed Elsevier Properties Inc, used under license. A Reed Business Information Publication/Volume 51, Number 1 (Printed in USA).

Design Today, Prototype Tomorrow

Superior Design Tools and Resources for the Analog Designer





WEBENCH® Online Tools

Get to market faster by accelerating your design process. WEBENCH® tools allow you to select products, design, and receive a custom prototype kit in 24 hours.
webench.national.com



Application Solutions

Over 100 interactive system block diagrams with a list of recommended parts for: automotive, broadcast video, data communications, displays, industrial, medical, and consumer applications.
solutions.national.com



24/7 Online Seminars

View over 50 on-demand design focused seminars for power, amplifiers, audio, data acquisition, interface, and thermal management.
www.national.com/onlineseminar



Analog University®

Get your design right the first time. Log on to Analog University for fast, free information from the pros at National, including in-depth design courses.
analogU.national.com

National Semiconductor

© National Semiconductor Corporation, 2006. National Semiconductor, N, WEBENCH, and Analog University are registered trademarks of National Semiconductor Corporation. All rights reserved.

EDN online contents
www.edn.com

ONLINE ONLY

Check out these online-exclusive articles:

IP and EDA start-up wants to make SOCs asynchronous

Silistix, an IP-bus and EDA start-up originating from research performed by the University of Manchester and funded by Intel Capital, wants to help you make the next generation of SOCs (systems on chips) asynchronous.
→www.edn.com/article/CA6292075

IEEE makes SystemC an official standard

The Open SystemC Initiative is seeing its hard work finally pay off as this week the IEEE has made SystemC an official standard.
→www.edn.com/article/CA6290389

RSS FEEDS

XML

Sign up for *EDN*'s RSS feeds and find out about new articles and blog posts as soon as we publish them.

Here's the address for our main headline feed:
→www.edn.com/EDN electronics.xml?nid=2551

Visit this page to find all of our feeds, plus an introduction to the pleasures of RSS:
→www.edn.com/rss

HOT 100

AUDIOCAST: *EDN*'s HOT 100 PRODUCTS OF 2005

In case you missed it, *EDN* published its annual list of the 100 most significant products of the past year in the December 16, 2005, issue. Check out the URL below to review the products that made the cut. While you're there, click on the "audiocast" link to hear Editor in Chief Maury Wright comment on some of the key products and the trends they represent.
→www.edn.com/article/CA6290449

Tell your *Tale*, earn a $200 American Express gift check

Submit your own **Tale from the Cube**, and, if we accept it for publication, you'll receive a $200 American Express gift check. Check out this issue's installment (pg 38) and the examples below, then contact Editor in Chief Maury Wright (mgwright@edn.com) with your Tale.

Skunkworks project ends up smelling like a rose
→www.edn.com/article/CA6288055

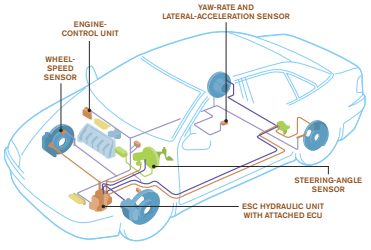
Parts are parts
→www.edn.com/article/CA6280049



FROM THE VAULT

Articles and extras from the EDN *archives that relate to this issue's contents.*

DESIGN CHALLENGES STEER AUTOMOTIVE ELECTRONICS (pg 61):



Traction control: It's all about μ
→www.edn.com/article/CA6250018

Automotive FPGA family gets high-end models
→www.edn.com/article/CA6262488

Black boxes capture car-crash data, controversy
→www.edn.com/article/CA529380

Engines of change: Microcontrollers evolve for the open road
→www.edn.com/article/CA608880

Electronics challenge the car's power grid
→www.edn.com/article/CA608888

CHOOSING HIGH-SPEED AMPLIFIERS FOR NOISE-SENSITIVE APPLICATIONS (pg 41):

The taming of the slew
→www.edn.com/article/CA323017

DESIGNING RF-IC FILTERS USING AN AUTOMATED CIRCUIT AND LAYOUT SYNTHESIS (pg 71):

Cadence spins design kit for RF design
→www.edn.com/article/CA6291134

Tight squeeze: RF design
→www.edn.com/article/CA336864

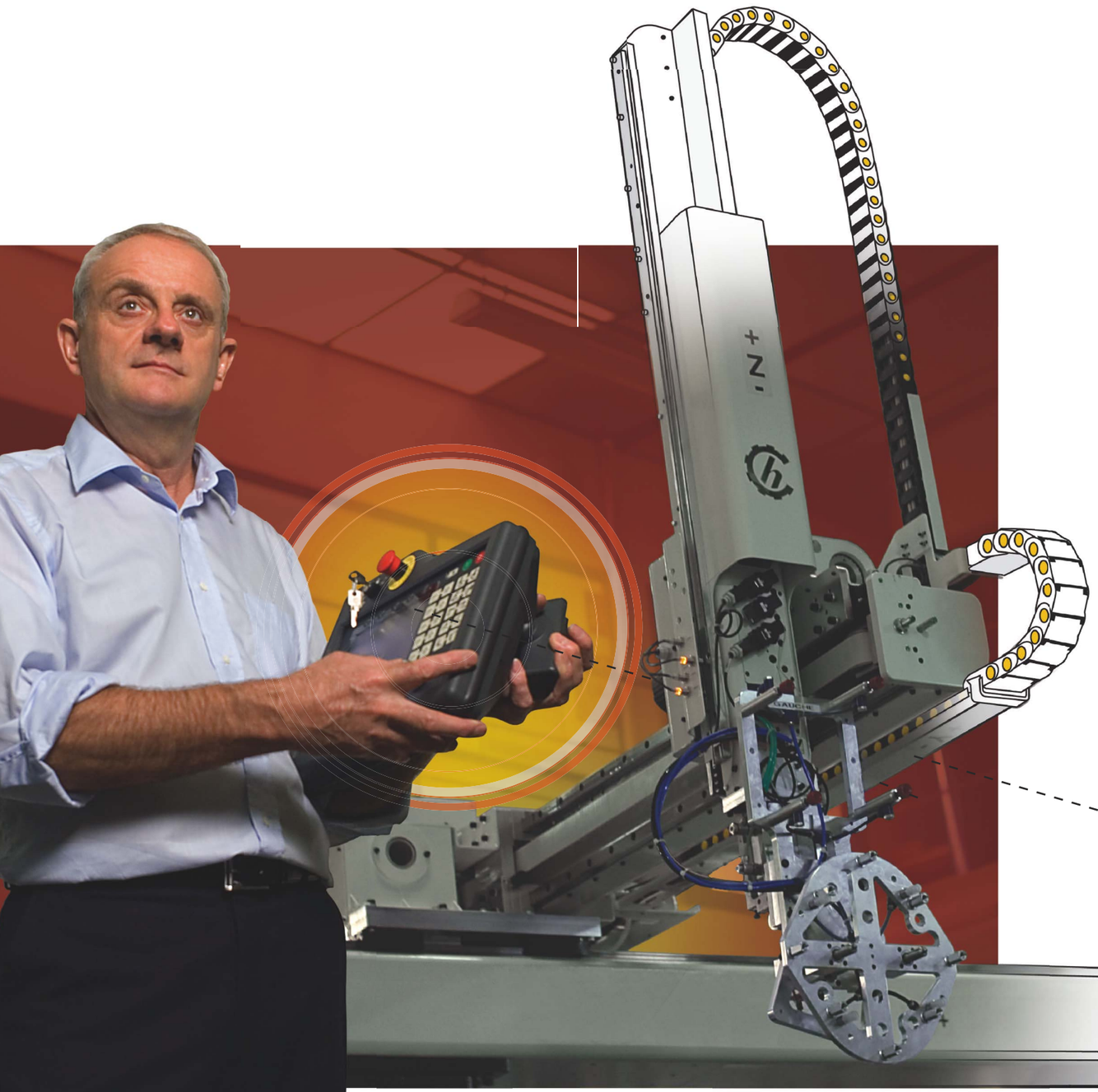
SERIAL STREAMS SHRINK EMBEDDED-SYSTEM DESIGNS (pg 52):

Pump it up: PCI Express
→www.edn.com/article/CA316047

Fabric technologies reach the mezzanine level
→www.edn.com/article/CA605525

Profit with plug-in processors
→www.edn.com/article/CA238439

Microsoft



We Put the Power of Windows Embedded in our Robots

Each day, device developers like Robert Bonin are harnessing the power of Microsoft® Windows Embedded to build great devices, like the latest industrial robots from Chaveriat Robotique.

Microsoft® Windows CE provides hard real-time capability to their robots and powers a user-friendly handheld device which enables factory floor personnel to make program changes on the fly. With these and other innovations based on Windows CE, Chaveriat Robotique has reasserted itself as a serious force in the world of robotic arms, with robots that are more functional and less expensive.

What's more, Windows Embedded offers the timesaving tools, operating system technologies and thousands of drivers device developers need—so that they have the power to truly innovate.

> ***"We chose Windows CE because it offers real-time and graphics at the right price."***
>
> — ROBERT BONIN / Research & Development Manager
> Chaveriat Robotique / France

The Power to Build Great Devices—get it with **Windows CE, Windows XP Embedded,** or **Windows Embedded for Point of Service.**

www.learnaboutembedded.com/robots

Windows Embedded

©2005 Microsoft Corporation. All rights reserved.

Microsoft, Windows CE and Windows Embedded are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries. The names of actual companies and products mentioned herein may be the trademarks of their respective owners.



BY MAURY WRIGHT, EDITOR IN CHIEF

802.11n progress: consensus building or end run?

The industry has well-documented the impasse in the IEEE 802.11n-standard development for next-generation WiFi wireless LANs. Intel and Broadcom led factions that agreed only to disagree. In the summer, the IEEE committee formed a joint-proposal group to bring consensus to the effort. Intel, along with conspirators Atheros and Broadcom, meanwhile, was planning an end run by privately developing a spec that it launched publicly under the EWC (Enhanced Wireless Consortium). The true motives of the players may never be fully evident, but it looks as though the EWC play will win the day.

When the EWC story broke in October, I wondered what could convince Broadcom and Intel to suddenly become partners. I speculated that the success that Airgo Networks was having with its MIMO (multiple-input, multiple-output) technology led to the unlikely partnership (**Reference 1**). I've had several EWC players try to convince me of a different sequence of events.

According to Atheros CTO William McFarland, Intel and Atheros early this year began work on what became the EWC to prove interoperability. The two companies agreed to separately build products to what had been the Intel-led TGn Sync proposal to 802.11.

This industry doesn't always keep secrets well, and players often strategically leak information. It's unclear how Broadcom learned of Intel's and Atheros' efforts, but McFarland claims they led Broadcom to ask to participate, and the EWC was formed. Broadcom may have been afraid that Intel and Atheros were close to launching proprietary products attempting to create a de facto standard.

Broadcom may have been afraid that Intel and Atheros were close to launching proprietary products attempting to create a de facto standard.

When the companies launched EWC, some participants in the IEEE joint-proposal group were blatantly unhappy. At the time, Greg Raleigh, Airgo president and CEO, lamented that the joint-proposal group was finally making progress and that the EWC would simply derail that progress. Others, such as participants from the mobile-phone and consumer-electronics communities, were upset that the EWC spec lacked provisions critical to the integration of 802.11n into handsets and to the use of 802.11n for carrying video in the home.

Fast-forward, and the EWC group claims to have taken steps to appease the handset and consumer factions. McFarland claims that the EWC founders started with a basic spec to achieve compromise and consensus. The EWC has agreed to add provisions for the other constituencies, although it is still working out some of the details.

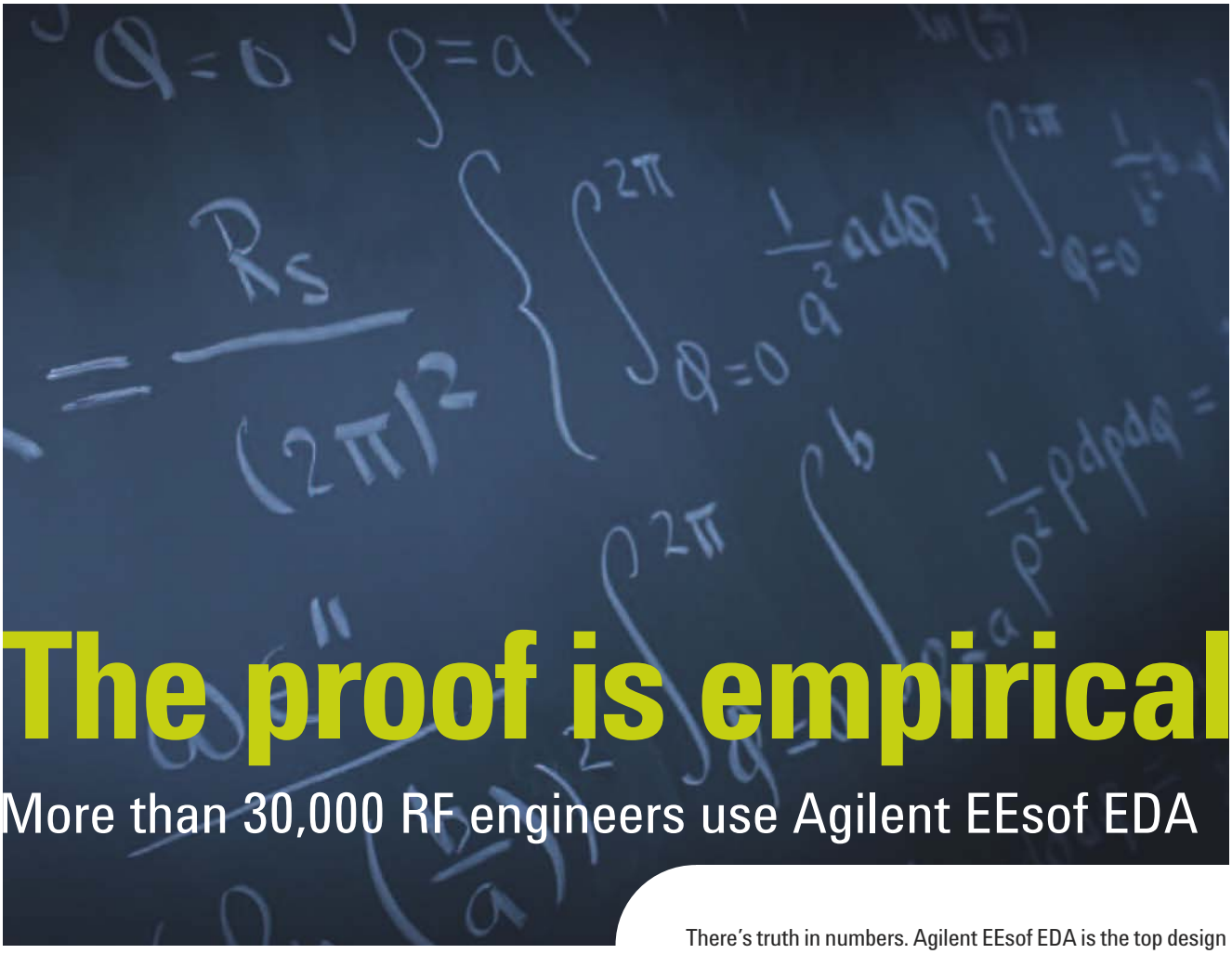
Airgo, meanwhile, still hasn't joined the EWC. Beau Beck, Airgo's vice president of business development, contends that Airgo would gain little at this point by doing so. In fact, he claims, the EWC has basically evolved to the point at which the joint-proposal team stood earlier in the year. After the November meeting of the IEEE 802.11n committee in Vancouver, the EWC claimed that the joint proposal and EWC specs "are approximately 85% aligned."

So why did the EWC start? I still think fear of Airgo was a factor. I also suspect that Intel figured it could use the strategy to get a jump-start in building 802.11n chips. But Airgo's Beck states, "If you build what you called out in June, then it's not going to be compatible with the EWC spec today."

Still, I expect MIMO chips from numerous sources before 802.11n becomes a reality. Start-up Metalink is already claiming compatibility with the draft standard with two ICs. I'd expect an announcement from Atheros and Marvell soon. And I'm betting that Intel is hoping that this impasse and end run will finally allow it to get in the wireless game. Yeah, I know all about Centrino. But many Centrino notebooks have Intel 802.11 inside, and the company has stumbled badly technologywise in 802.11. But perhaps that's a topic for another column. EDN

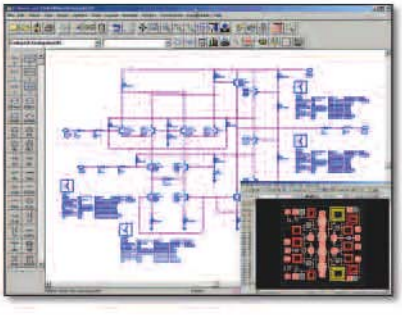
REFERENCE

1 Wright, Maury, "Intel and Broadcom push new WLAN spec, fear makes strange bedfellows," Oct 10, 2005, www.edn.com/blog/150000015/post/1610001561.html.



The proof is empirical

More than 30,000 RF engineers use Agilent EEsof EDA



EAGLEWARE ELANIX

Eagleware-Elanix is now part of Agilent EEsof EDA.

There's truth in numbers. Agilent EEsof EDA is the top design software choice among engineers for the vast majority of the world's wireless devices.

The fact is derived from software products with undisputed breadth of functionality. Agilent EEsof EDA applications were created for RF engineers by RF engineers. They have the capabilities you need the most. And now with the addition of Eagleware-Elanix you have further ease of use, new synthesis technology, and additional pricing options other products can't touch. Agilent's team of EDA experts releases multiple improvement updates each year. And Agilent has the largest number of technology partners, application examples, and technical articles in the industry.

Work the proof yourself. Agilent EEsof EDA can be customized to fit the precise needs of your projects and budget. Visit www.agilent.com/find/eesof-innovations to find out more.

www.agilent.com/find/eesof-innovations

© Agilent Technologies, Inc. 2005

Agilent Technologies

Transformer-like performance at a fraction of the cost



InGenius®

High Common-Mode Rejection Ratio Differential Input Line Receivers

- 90dB CMRR under real-world conditions
- Wide bandwidth: >22 MHz
- High slew rate: 12 V/µs
- Low distortion: 0.0005% THD
- Low noise: -107 dBu

THAT Corporation

Analog Circuits Made Easy™

www.thatcorp.com

THAT, InGenius and (T) are registered trademarks of THAT Corporation

PC-HOSTED LOGIC ANALYZER

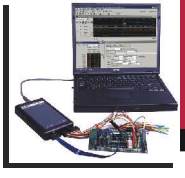
Digital Test, Easy and Simple

Trigger DSO and View Data with Waveforms

- 72 Channels @250MHz
- 36 Channels @ 500MHz
- Up to 4 Meg/Channel
- Transitional Timing



See the solution quickly



"Your Eyes into the Digital World"

NCI Logic Analyzers

www.nci-usa.com

Phone 256-837-6667 • Fax 256-837-5221

email: contact @nci-usa.com

EDN

PUBLISHING DIRECTOR, *EDN* WORLDWIDE
John Schirmer
jschirmer@reedbusiness.com;
1-408-345-4402; fax: 1-408-345-4400

EDITOR IN CHIEF
Maury Wright, 1-858-748-6785
mgwright@edn.com

MANAGING EDITOR
Kasey Clark
1-781-734-8436; fax: 1-781-290-3436;
kase@reedbusiness.com

EXECUTIVE EDITOR, ONLINE
Matthew Miller
1-781-734-8446; fax: 1-781-290-3446;
mdmiller@reedbusiness.com

SENIOR ART DIRECTOR
Mike O'Leary
1-781-734-8307; fax: 1-781-290-3307;
moleary@reedbusiness.com

EMBEDDED SYSTEMS
Warren Webb, Technical Editor;
1-858-513-3713; fax: 1-858-486-3646
wwebb@edn.com

ANALOG/COMMUNICATIONS, DISCRETE SEMICONDUCTORS
Maury Wright, 1-858-748-6785;
mgwright@edn.com

EDA, MEMORY, PROGRAMMABLE LOGIC
Michael Santarini, Senior Editor;
1-408-345-4424
michael.santarini@reedbusiness.com

MICROPROCESSORS, DSPs, TOOLS
Robert Cravotta, Technical Editor;
1-661-296-5096; fax: 1-781-734-8070
rcravotta@edn.com

MASS STORAGE, MULTIMEDIA, PCs AND PERIPHERALS
Brian Dipert, Senior Technical Editor;
1-916-760-0159; fax: 1-781-734-8038;
bdipert@edn.com

POWER SOURCES, ONLINE INITIATIVES
Margery Conner, Technical Editor;
1-805-461-8242; fax: 1-805-461-9640;
mconner@connerbase.com

DESIGN IDEAS EDITOR
Brad Thompson
edndesignideas@reedbusiness.com

SENIOR ASSOCIATE EDITOR
Frances T Granville
1-781-734-8439; fax: 1-781-290-3439;
f.granville@reedbusiness.com

ASSOCIATE EDITOR
Maura Hadro Butler
1-908-928-1403;
mbutler@reedbusiness.com

WEB/CPS PRODUCTION COORDINATOR
Contact for contributed technical articles
Heather Wiggins
1-781-734-8448; fax: 1-781-290-3448;
hwiggins@reedbusiness.com

EDITORIAL AND ART PRODUCTION
Diane Malone, Manager; 1-781-734-8445
fax: 1-781-290-3445
Steve Mahoney, Production Editor
1-781-734-8442; fax: 1-781-290-3442
Adam Odoardi, Prepress Manager
1-781-734-8325; fax: 1-781-290-3325

CONTRIBUTING TECHNICAL EDITOR
Dan Strassberg, strassbergedn@att.net

COLUMNISTS
Howard Johnson, PhD;
Bonnie Baker; Joshua Israelsohn

PRODUCTION
Dorothy Buchholz, Group Production Director
1-781-734-8329
Kelly Brashears, Production Manager
1-781-734-8328; fax: 1-781-734-8086
Linda Lepordo, Production Manager
1-781-734-8332; fax: 1-781-734-8086
Pam Boord, Advertising Art
1-781-734-8313; fax: 1-781-290-3313

EDN EUROPE
Graham Prophet, Editor, Reed Publishing
The Quadrant, Sutton, Surrey SM2 5AS
+44 118 935 1650; fax: +44 118 935
1670; gprophet@reedbusiness.com

EDN ASIA
Raymond Wong, Managing Director/
Publishing Director
raymond.wong@rbi-asia.com
Kirtimaya Varma, Editor in Chief
kirti.varma@rbi-asia.com

EDN CHINA
William Zhang, Publisher and Editorial Director
wmzhang@idg-rbi.com.cn
John Mu, Executive Editor
johnmu@idg-rbi.com.cn

EDN JAPAN
Katsuya Watanabe, Publisher
k.watanabe@reedbusiness.jp
Kenji Tsuda, Editorial Director
and Editor in Chief
tsuda@reedbusiness.jp
Takatsuna Mamoto, Deputy Editor in Chief
t.mamoto@reedbusiness.jp



The EDN *Editorial Advisory Board serves as an industry touchstone for the editors of* EDN *worldwide, helping to identify key trends and voicing the concerns of the engineering community.*

DENNIS BROPHY
Director of Business Development
Mentor Graphics

DANIS CARTER
Principal Engineer, Tyco Healthcare

CHARLES CLARK
Technical Fellow, Pratt & Whitney Rocketdyne

DMITRII LOUKIANOV
System Architect, Intel

RON MANCINI
Staff Scientist, Texas Instruments

GABRIEL PATULEA
Design Engineer, Cisco

MIHIR RAVEL
VP Technology, National Instruments

DAVE ROBERTSON
Product Line Director, Analog Devices

SCOTT SMYERS
VP Network and System Architecture Division, Sony

TOM SZOLYGA
Program Manager, Hewlett-Packard

JIM WILLIAMS
Staff Scientist, Linear Technology

EDN. 225 Wyman St, Waltham, MA 02451. **www.edn.com**. Phone 1-781-734-8000; fax: 1-781-734-8070. **Address changes or subscription inquiries:** phone 1-800-446-6551; fax: 1-303-470-4280; subsmail@reedbusiness.com. For a free subscription, go to **www.getfreemag.com/edn**. Reed Business Information, 8878 S Barrons Blvd, Highlands Ranch, CO 80129-2345. Include your mailing label.

Reed Electronics Group

SIGNAL PATH designer℠

Tips, tricks, and techniques from the analog signal-path experts

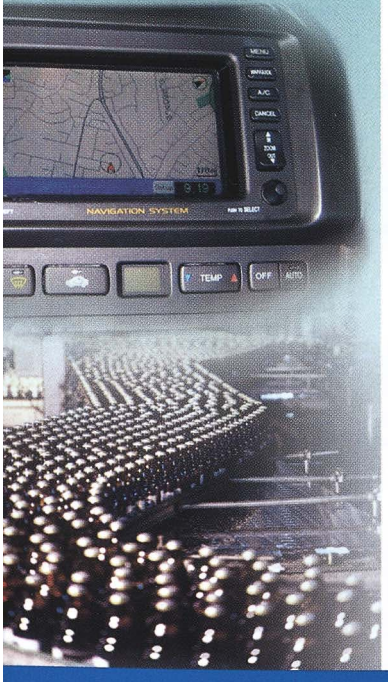
No. 104

Feature Article 1-7

Telecommunications ..2

Industrial Diagnostics and Factory Automation....4-5

Design Tools 8



Improving Machinery Vibration Analysis

— By Walter Bacharowski, Applications Engineer

Machinery downtime during normal shift operations is very costly due to lost production, but it is also avoidable. Preventative maintenance systems are being used to improve the operating efficiency of machinery used in factories, power plants, mining, and many other operations.

Diagnostic electronics, used in newer preventative maintenance programs, monitor the operating parameters of the machine. For example, a roller mill may have several large electric motors and rollers, all of which have bearings, a hydraulic pump, and a variety of hydraulic actuators. A preventative maintenance system for this type of equipment could include electronic monitoring equipment to measure bearing vibration and temperature, hydraulic fluid pressure and temperature, and motor temperature.

Vibration analysis, which is the measurement of vibrations generated by moving parts in the frequency range of 50 Hz to 10 kHz, can be used to monitor the condition of bearings and other moving components. Ultrasonic analysis, an extension of vibration analysis, uses higher frequencies in the 15 kHz to 40 kHz range. Changes are detected through spectral analysis of the generated frequencies in the moving components due to wear or damage. As parts wear, the magnitude of the vibrations and ultrasonic noise will increase. An increase of about 12 dB indicates possible impending failure.

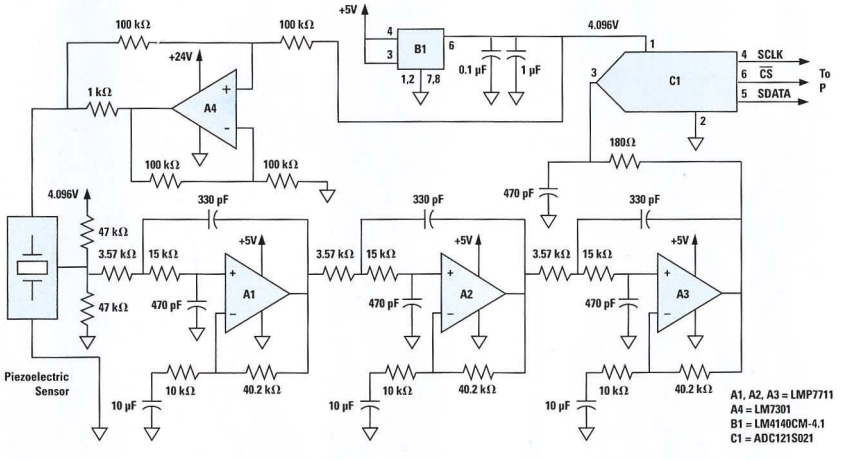


Figure 1. Vibration Analysis Signal Chain

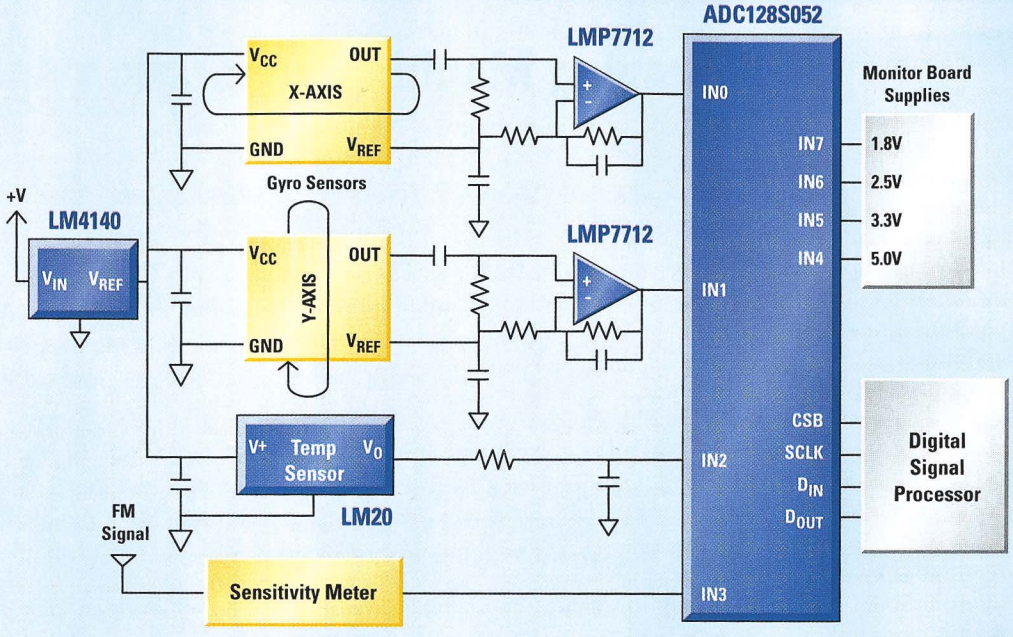
NEXT ISSUE:

LIDAR/Radar Design

National Semiconductor

Signal-Path Solutions for Telecommunications

GPS Application



Precision Amplifiers

Product ID	Key Features	Typ Supply Current (mA)	Supply Voltage Range (V)	Max Input Offset Voltage (mV)	Unity Gain Bandwidth (MHz)	Low Input Current CMOS Design	Temp Range (°C)
LMP7712	Precision, low-noise RRO dual CMOS	1.15	1.8 to 5.5	0.15	17	✔	-40 to +125
LMP7702	Precision, 12V RRIO dual CMOS	0.73	2.7 to 12	0.2	2.5	✔	-40 to +125
LMP2012	90% power saving RRO performance amp	1.2	2.7 to 5.25	0.025	3	—	-40 to +125

Serial Peripheral Interface (SPI) ADCs for 8-Channel Applications

Product ID	Res	# of Inputs	Pin/Function Compatible	Throughput Rate (kSPS)	Input Type	Max Power 5V/3V (mW)	Supply (V)	Max INL (LBS)	Min SINAD (dB)	Packaging
ADC78H90	12	8		500	Single ended	12/8.3	2.7 to 5.25	±1.0	70	TSSOP-16
ADC128S102	12	8		500 to 1000	Single ended	15.5/4.5	2.7 to 5.25	±1.2	70	TSSOP-16
ADC128S052	12	8		200 to 500	Single ended	13/3.6	2.7 to 5.25	±1.0	70	TSSOP-16
ADC128S022	12	8		50 to 200	Single ended	11.5/3.3	2.7 to 5.25	±1.0	70	TSSOP-16
ADC108S102	10	8		500 to 1000	Single ended	13.6/4.2	2.7 to 5.25	±0.5	61.3	TSSOP-16
ADC108S052	10	8		200 to 500	Single ended	12.1/3.3	2.7 to 5.25	±0.4	61.3	TSSOP-16
ADC108S022	10	8		50 to 200	Single ended	10.5/2.8	2.7 to 5.25	±0.3	61.3	TSSOP-16
ADC088S102	8	8		500 to 1000	Single ended	11/3.6	2.7 to 5.25	±0.2	49.2	TSSOP-16
ADC088S052	8	8		200 to 500	Single ended	8.5/3	2.7 to 5.25	±0.2	49.2	TSSOP-16
ADC088S022	8	8		50 to 200	Single ended	7.8/2.2	2.7 to 5.25	±0.2	49.2	TSSOP-16

Improving Machinery Vibration Analysis

This type of monitoring allows repairs to be made before the component fails. In many cases, vibration analysis and ultrasonic analysis require two different pieces of equipment. A single, cost-effective instrument that can monitor the complete frequency range would be useful. A schematic diagram of a vibration and ultrasonic analysis signal chain is shown in ***Figure 1***.

The piezoelectric sensor senses the vibrations and ultrasonic noise generated by the bearings. The piezoelectric element is buffered internally by a MOSFET, which is driven by a constant current source, amplifier A4, and is internally AC coupled to the filter. Amplifiers A1, A2, and A3 implement a gain of 41.9 dB in conjunction with a 6-pole low-pass filter. The ADC121S021 Analog-to-Digital Converter (ADC), which operates at a 200 kHz sampling rate, digitizes the amplified and filtered signal. The microprocessor's software performs a FFT (Fast Fourier Transform) on the data to obtain the frequency and magnitude information. The pass band of the circuitry shown is about 40 kHz. A typical wide band vibration sensor has a transfer function in the form of ***Figure 2***.

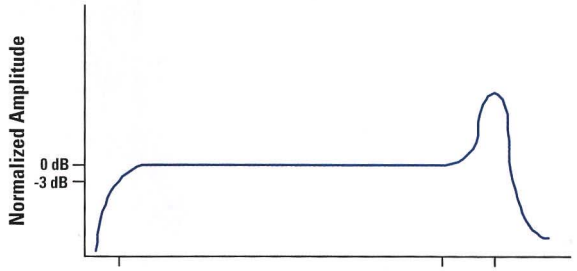


Figure 2. Sensor Transfer Function

The low frequency will start to roll off around 30 Hz and will be relatively flat until a resonance frequency occurs at 65 kHz, after which the response falls rapidly. The peak-to-peak amplitude in the flat band is about 32 mV_{P-P} and will be amplified to 4 V_{P-P}. The gain will be:

$$\frac{4.096\,V}{0.032} = 128$$

A gain of 125 will be used to provide some margin.

In relation to the maximum signal frequency of interest, 40 kHz in this case, the sampling rate is a concern. To avoid aliasing frequencies higher then the Nyquist rate, ½ the sampling frequency must be filtered and reduced in amplitude to less then 1 LSB of the ADC. In this example, a 12-bit ADC is being used with a 4.096V reference, which results in a resolution of 1 mV as follows:

$$\frac{4.096\,V}{4096} = 0.001\,V$$

To have a realizable filter in sampled data systems, there must be some separation between the highest frequency to be measured and the Nyquist frequency of the ADC. The result is over sampling the signal, but the filter can reduce or eliminate aliasing. ***Figure 1*** uses the ADC121S021, which is a 12-bit, 200k Samples Per Second (kSPS) ADC. When this ADC is converting at 200 kSPS, the Nyquist frequency will be 100 kHz. The output signal of the sensor is about 8 mV_{P-P} at 100 kHz and the gain required to reduce this signal to less then 1 mV_{P-P} is:

$$20\log\left(\frac{0.001\,V}{0.008\,V}\right) = -18\ dB$$

The difference between the 100 kHz and the 40 kHz signal is 60 kHz or 0.6 of a frequency decade. At 40 kHz, the gain is:

$$20\log\left(125\,V/V\right) = 41.9\ dB$$

The required filter roll off is:

$$\frac{(-41.9\ dB + (-18\ dB))}{0.6\ decade} = -99.8\ dB/decade$$

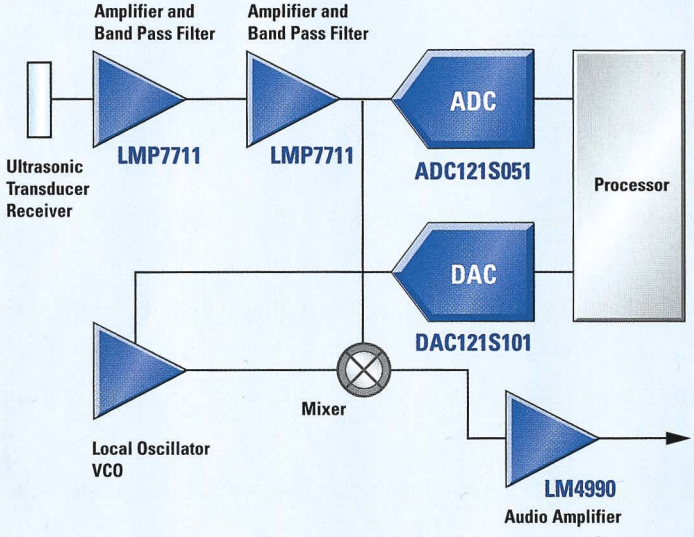
Or at least a 5-pole filter:

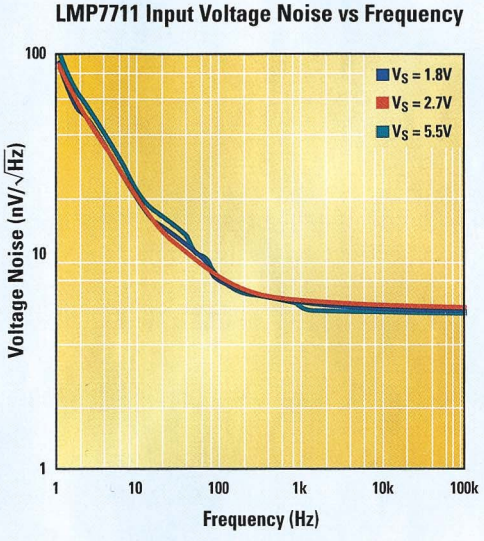
$$\frac{-99.8\ dB/decade}{-20\ dB/decade/pole} = 4.99\ poles$$

An amplifier can easily implement a 2-pole filter, so three amplifiers will be used, resulting in each amplifier having a pass band gain of 5. The pass band characteristic of the filter is a result of the gain bandwidth of the amplifier and the placement

Signal-Path Solutions for Industrial Diagnostics and Factory Automation

Ultrasonic Receiver and Spectral Analyzer





LMP7711 Features

- Offset voltage, V_{OS}, less than 150 µV for better initial accuracy
- Maximum TCV_{OS} of 4 µV/°C ensures accuracy from -40°C to 125°C
- Low 1/f noise at 6.8 nV/√Hz at 1 kHz
- Ultra-low input bias current, 100 fA, for high impedance sensor interfacing

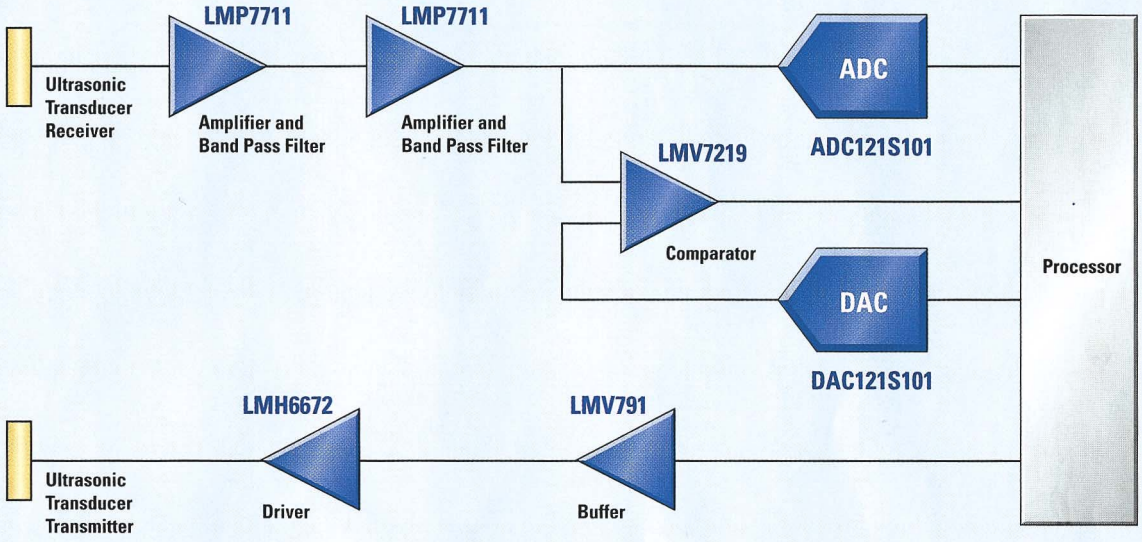
LMP7701 Features

- Offset voltage, V_{OS}, less than 300 µV for better initial accuracy
- Guaranteed 2.7V to 12V operation over -40°C to 125°C
- Ultra-low input bias current, 200 fA, for high impedance sensor interfacing
- High PSRR (110 dB) ensures higher accuracy with noisy supplies
- High CMRR (110 dB) ensures high accuracy over a wide input range

Precision Op Amps

Product ID	Key Features	Typ Supply Current (mA)	Supply Voltage Range (V)	Max Input Offset Voltage (mV)	Unity Gain Bandwidth (MHz)	Low Input Current CMOS Design	Temp Range (°C)
LMP7711	Precision, low-noise RRO CMOS	1.15	1.8 to 5.5	0.15	17	✔	-40 to +125
LMP7701	Precision, 12V RRIO CMOS	0.73	2.7 to 12	0.2	2.5	✔	-40 to +125
LMV651	90% Power saving RRO performance amp	0.11	2.7 to 5.5	1.0	12	—	-40 to +125
LMV791	Low-noise, low I_{BIAS} RRO	0.95	1.8 to 5.5	1.3	14	✔	-40 to +125
LPV511	880 nA, Ultra-low power 12V RRIO	880 nA	2.7 to 12	3.0	0.027	—	-40 to +85

Distance and Speed Measurement Application



Serial Peripheral Interface (SPI) ADCs and DACs for Single-Channel Applications

- Guaranteed performance over sample rates
- Excellent static and dynamic performance
- Miniature packages reduce board space
- Pin- and function-compatible family
- Extremely low power
- Reference from supply

ADCs for Single-Channel Applications

Product ID	Res	# of Inputs	Pin/Function Compatible	Throughput Rate (kSPS)	Input Type	Max Power 5V/3V (mW)	Supply (V)	Max INL (LBS)	Min SINAD (dB)	Packaging
ADC121S101	12	1		500 to 1000	Single ended	16/4.5	2.7 to 5.25	±1.1	70	SOT23-6, LLP-6
ADC121S051	12	1		200 to 500	Single ended	15.8/4.7	2.7 to 5.25	±1.0	70.3	SOT23-6, LLP-6
ADC121S021	12	1		50 to 200	Single ended	14.7/4.3	2.7 to 5.25	±1.0	70	SOT23-6, LLP-6
ADC101S101	10	1		500 to 1000	Single ended	16/4.5	2.7 to 5.25	±0.7	61	SOT23-6
ADC101S051	10	1		200 to 500	Single ended	13.7/4.3	2.7 to 5.25	±0.7	60.8	SOT23-6
ADC101S021	10	1		50 to 200	Single ended	12.6/4	2.7 to 5.25	±0.6	60.7	SOT23-6
ADC081S101	8	1		500 to 1000	Single ended	16/4.5	2.7 to 5.25	±0.3	49	SOT23-6
ADC081S051	8	1		200 to 500	Single ended	12.6/3.6	2.7 to 5.25	±0.3	49	SOT23-6
ADC081S021	8	1		50 to 200	Single ended	11.6/3.24	2.7 to 5.25	±0.3	49	SOT23-6
ADC121S625*	12	1		50 to 200	Differential	2.8	4.5 to 5.5	±1.0	68.5	MSOP-8

*Uses external reference

DACs for Single-Channel Applications

Product ID	Res	# of Inputs	Pin/Function Compatible	Settling Time (µs)	Input Type	Max Power 5V/3V (mW)*	Supply (V)	Max INL (LBS)	Max DNL (LBS)	Packaging
DAC121S101	12	1		10	Single ended	1.5/0.7	2.7 to 5.5	±8.0	+1.0/-0.7	SOT23-6, MSOP-8
DAC101S101	10	1		7.5	Single ended	1.6/0.7	2.7 to 5.5	±2.8	+0.35/-0.2	SOT23-6, MSOP-8
DAC081S101	8	1		5	Single ended	1.6/0.7	2.7 to 5.5	±0.75	±0.1	SOT23-6, MSOP-8

*F_{SCLK} = 20 MHz

Improving Machinery Vibration Analysis

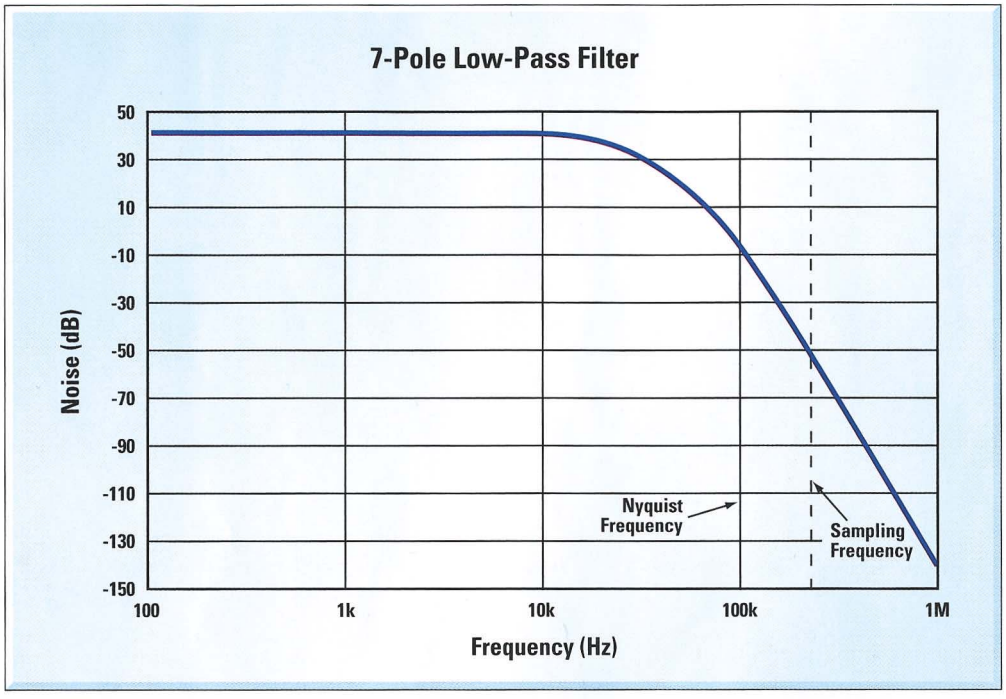


Figure 3. 7-Pole Low-Pass Filter

of the poles in the amplifier's feedback. Each filter stage can be considered as a non-inverting gain stage of 5V/V with two poles. The gain bandwidth of the amplifier required to keep the amplitude error less then 1 LSB at 40 kHz can be calculated as follows:

$$\frac{40\,\text{kHz} \times 5}{0.0156} = 12820\ \text{kHz} = 12.8\ \text{MHz}$$

The denominator, 0.0156, in the previous calculation is the effective bandwidth of an amplifier for 13-bit accuracy given its -3 dB point. The LMP7711 precision amplifier, with 17 MHz gain bandwidth and a typical offset voltage of 20 µV, is a good choice for this type of application. The output of amplifier A3 is isolated from the switched capacitor input of the ADC by the 180Ω resistor and the 470 pF capacitor which adds an additional pole to the anti-alias filter. ***Figure 3*** shows the estimated response of the low-pass filter.

The ADC121S021 is a single-ended input, 12-bit, 200 kSPS converter with a Serial Peripheral Interface (SPI). An LM4140ACM-4.1 precision voltage reference is the ADC's reference and biases the filter amplifiers to half of the ADC's input range. The sensor's output is an AC signal, and the mid-scale offset level shifts the signal to the center of the ADC's range. The LM4140 is also the reference voltage for the voltage controlled current source using the LM7301, amplifier A4, a general purpose 32V amplifier. Internal to the sensor, a MOSFET transistor buffers the piezoelectric sensor element. The current source drives the MOSFET, which is connected as a common source amplifier and is AC coupled to the output terminal.

Another aspect of machine monitoring is the measurement and analysis of hydraulic pressure transients in hydraulic control systems. For example, hydraulic hammer occurs when flow control valves have a fast shutoff and the fluid momentum causes a banging effect within the fluid system. Hydraulic hammer can damage and cause premature failure of hydraulic components and systems. These systems are designed to safely absorb the hydraulic energy. ***Figure 4*** is a schematic of a hydraulic pressure monitoring system.

This signal chain can be used to monitor pressure fluctuations as well as to conduct spectral analysis of the pressure fluctuations. As in ***Figure 1***, the frequency response of the sensor and amplifier must eliminate frequency components above the Nyquist frequency. In this case, the frequency response of the pressure sensor and the hydraulic system naturally band limit the pressure signals to about 3 kHz to 4 kHz. This reduces the filter requirements of the amplifier circuits. This amplifier, made up of A1 and A2, is the input stage of an instrumentation amplifier and provides a differential input and a differential output with a gain of 100V/V. The 200 pF capacitors provide a pole at 8 kHz for additional filtering. The amplifiers' outputs are isolated from the switched capacitor inputs of the ADC by the 180Ω resistors and the 470 pF capacitors.

The pressure sensor in this example is a resistive bridge and the sensor's output is a function of the change in resistance and the voltage driving it. The sensor used in ***Figure 3*** has a sensitivity of 0.2 mV/V of bridge excitation voltage per PSI of pressure. The DAC081S101 is an 8-bit DAC and is used to change the voltage driving the bridge which has the effect of a gain control for the pressure measurement circuit. For example, if the DAC's output is programmed to 4V, then the full-scale pressure is 25.6 PSI. With an output voltage of 1V, the full-scale pressure is 102 PSI.

In summary, the circuitry shown can be used to implement a cost-effective, dedicated machine monitoring system. ■

View over 50 on-demand design focused seminars at www.national.com/onlineseminar

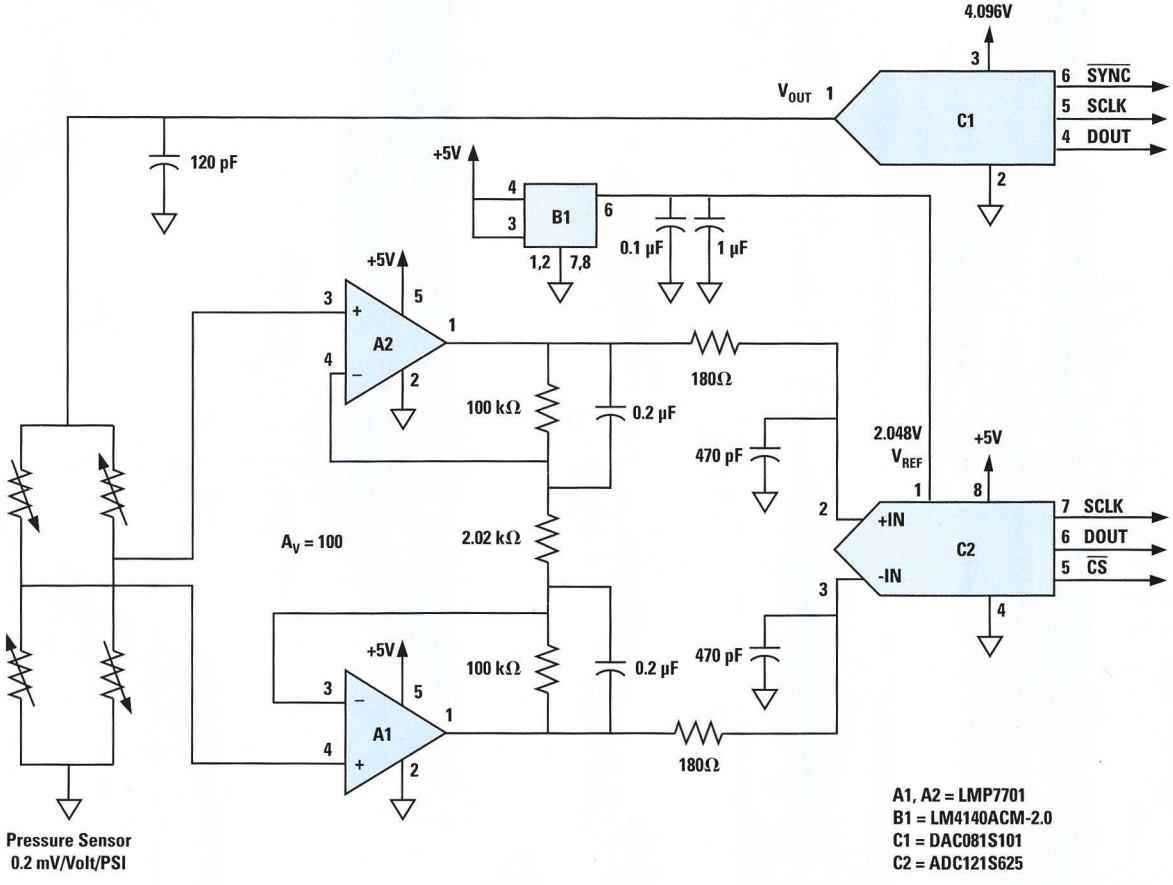
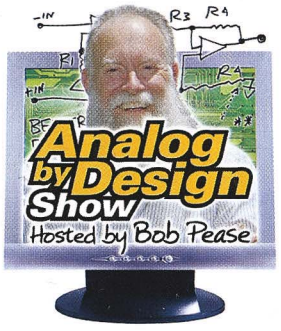


Figure 4. Hydraulic Pressure Monitoring System

Design Tools

INTRODUCING...



The Analog by Design Show

Tune in to National's Analog by Design Show, hosted by Bob Pease, for in-depth technical discussion and lab demonstrations including:

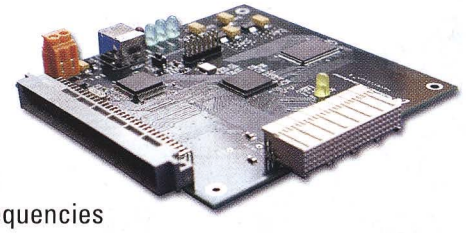
- How not to design a noise-amplifying preamplifier
- How to properly specify a low-noise op amp
- How to test whether an op amp model includes effects of noise
- New WEBENCH® Low-Pass Active Filter Evaluation Board
- Compare WEBENCH simulation results with bench-test results

WEBENCH Active Filter Designer speeds the creation of sophisticated filters for data acquisition and signal conditioning applications.

Check out the new episode at **www.national.com/nationaltv**

WaveVision 4.0 Evaluation Board

Test and evaluate A/D converters with National's easy-to use WaveVision 4.0 evaluation board. Each evaluation board comes complete with USB cable and support software.



Features and benefits:

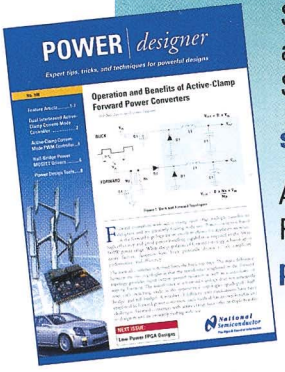
- Plug-n-play ADC evaluation board
- USB interface to PC
- PC-based data capture
- Easy data capture and evaluation
- Highlighted harmonic and SFDR frequencies
- Easy waveform examination
- Produces and displays FFT plots
- Dynamic performance parameter readout with FFT
- Produces and displays histograms

National Semiconductor
2900 Semiconductor Drive
PO Box 58090
Santa Clara, CA 95052
1 800 272 9959

Visit our website at:
signalpath.national.com

For more information, send email to:
new.feedback@nsc.com

Don't miss a single issue!



Subscribe now to receive email alerts when new issues of Signal Path Designer℠ are available:

signalpath.national.com/designer

Also, be sure to check out our Power Designer! View online today at:

power.national.com/designer



National Semiconductor

© National Semiconductor Corporation, 2006. National Semiconductor, N, LMP, and WEBENCH are registered trademarks of National Semiconductor.
Signal Path Designer is a service mark of National Semiconductor. All other brand or product names are trademarks or registered trademarks of their respective holders.

ALPS®

Playing a major part in the next generation of communications.

Through advancing a diverse range of technologies for the fast-paced communications and broadcasting fields, ALPS is helping turn the dream of a comprehensive multimedia society into a reality.

Components for telecommunications





Bluetooth™ module

Components for broadcasting





Built-in demodulator tuner for digital terrestrial broadcasting

Components for optical communications





Optical communication lenses

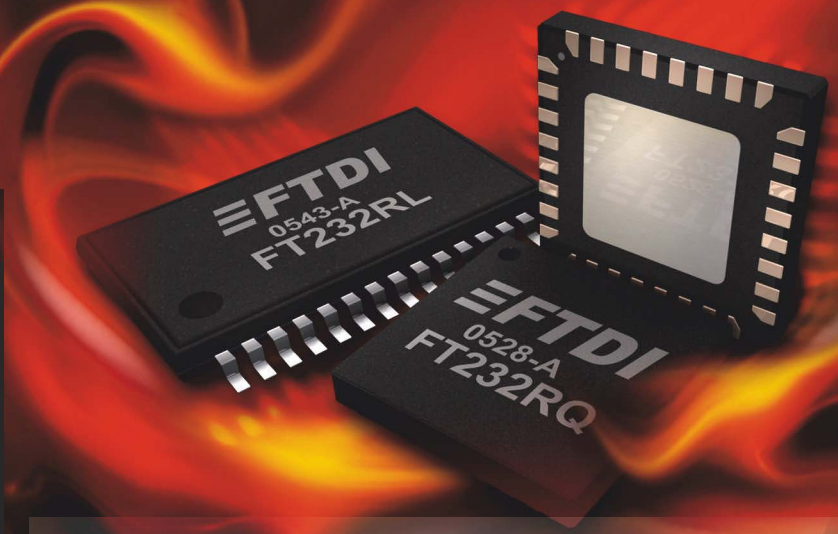
Bluetooth™ is a trademark owned by Telefonaktiebolaget L M Ericsson, Sweden and licensed to ALPS ELECTRIC CO., LTD.

Visit our Web site for more details: **http://www.alps.com**

ALPS
ALPS ELECTRIC CO., LTD.

ALPS ELECTRIC (USA), INC. *http://www.alpsusa.com*
910 E. Hamilton Avenue Suite #500 Campbell, CA 95008, U.S.A. Phone +1(408)361-6400 Fax +1(408)226-7301
HEAD OFFICE *http://www.alps.co.jp*
1-7, Yukigaya-otsuka-cho, Ota-ku, Tokyo, Japan, 145-8501 Phone. +81(3)3726-1211 Fax. +81(3)3728-1741

FT232R USB UART with MCU Clock Generator and FTDIChip-ID™ Security Dongle



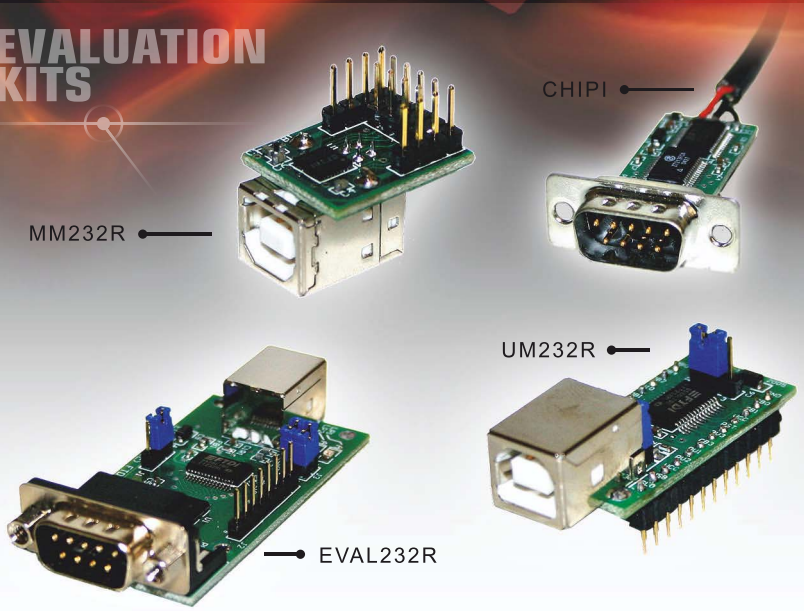
MORE

Integration - EEPROM, internal clock generator, and USB termination resistors on-chip.
Functionality - integrates the functions of USB UART, MCU clock generator and Security Dongle into a single chip.
Flexibility - five IO pins can each be user configured as Sleep, Transmit Enable, Power Enable, MCU Clock Output, TX/RX LED Drive or GPIO Pin
Security - FTDIChip-ID™ technology helps protect your application software.
I/O Drive Capability - from 5.5v down to 1.8v levels at 4mA or 12mA programmable strength.
I/O Modes - synchronous and asynchronous Bit-Bang I/O
OS Support - in house developed & supported drivers for Windows 98,ME,2K, Server 2003, XP, XP64, Embedded XP, Mac OS8,9,X, Linux, Win CE + many 3rd party drivers.
Driver Options - VCP and D2XX drivers for all Windows platforms and Linux.
Technical Support - a wide range of evaluation kits available from the outset make evaluating the FT232R a snap.
Package Choices - SSOP28 and QFN32
Interface Options - also available with a parallel FIFO interface
(p/n FT245R).

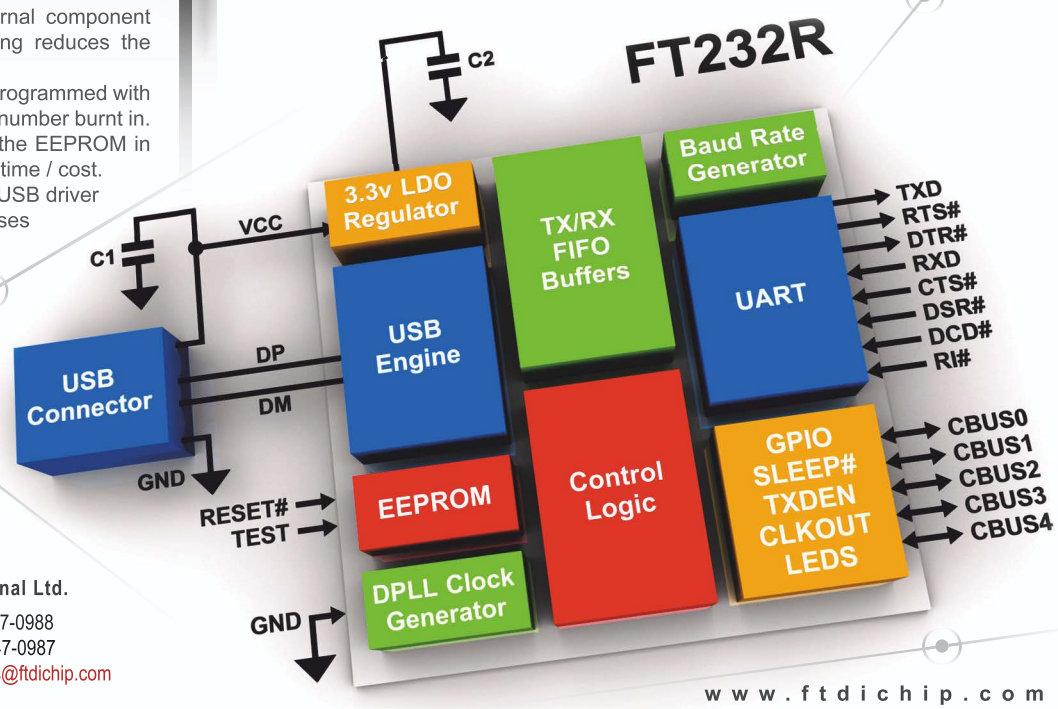
LESS

External Components - no crystal, EEPROM or USB termination resistors required.
Board Space - new QFN package takes up only 25mm² of pcb area.
Manufacturing Cost - minimal external component count coupled with competitive pricing reduces the overall cost.
Programming - FT232R comes pre-programmed with each part having a unique USB serial number burnt in. This eliminates the need to program the EEPROM in many cases and saves on production time / cost.
Time to Market - FT232R eliminates USB driver and firmware development in most cases thus significantly reducing time to market.

EVALUATION KITS



BLOCK DIAGRAM



FTDI Chip

USA Sales Office
Future Technology Devices International Ltd.

5285 NE Elam Young Parkway, Suite B800,
Hillsboro, OR 97124-6499
USA

Tel.: +1 (503) 547-0988
Fax: +1 (503) 547-0987
E-Mail : us.sales@ftdichip.com

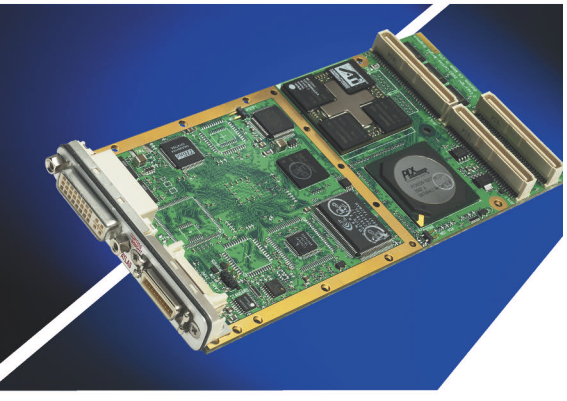
EDITED BY FRAN GRANVILLE

pulse

INNOVATIONS & INNOVATORS

PMC card fits multimedia applications

Curtiss-Wright Controls has introduced the AtlasPMC/2, a dual-channel, high-resolution PMC graphics controller featuring a range of multimedia features for VME, CompactPCI, and PCI systems. The company based the card on ATI Technologies' Radeon M9 mobile graphics processor, which supports dual 2-D-, 3-D-, OpenGL-, and DirectX-compatible displays with as many as 16.7 million colors. In addition to its 64 Mbytes of integrated memory, the Windows-compatible graphics processor delivers reduced-power features, integrated video output, and quad-pipeline 2-D/3-D acceleration.



Curtiss-Wright's new AtlasPMC/2 graphics card features VGA/DVI graphics, video/RGB/DVI input, audio I/O, and USB 2.0.

The AtlasPMC/2 displays analog VGA screen resolutions as great as 1920×1200 pixels over its front-panel DVI-I and MDR20 connectors. Designers can also configure the card to output dual DVI (digital-video-input) channels at resolutions as high as 1600×1200 pixels. The card's second channel supports NTSC and PAL TV-video-signal output. A USB 2.0 host controller and stereo-audio controller complete the card's multimedia features. Software drivers are compatible with the Solaris, Linux, Windows, VxWorks, and LynxOS operating systems. Price for the AtlasPMC/2 is $2500 (one).**—by Warren Webb**

▷**Curtiss-Wright Controls Embedded Computing**, www.cwcembedded.com.

ADC blazes at 190M samples/sec but sips power

The new ADS5546 ADC from Texas Instruments targets applications in wireless communications, video and imaging, test and measurement, and instrumentation. The chip offers 73.2-dB full-scale SNR and 84-dBc SFDR (spurious-free dynamic range) at the maximum sample rate of 190M samples/sec with an input frequency of 70 MHz. The ADS5546 has user-selectable CMOS or DDR LVDS outputs. "The output flexibility of the ADS5546 makes it possible to interface with a variety of TI's DSPs for signal postprocessing," says TI's Yiannis Papantonopoulos, systems and applications manager for high-speed DACs. In addition, the device includes internal sample and hold, a low-jitter clock buffer, and internal or external reference capability.

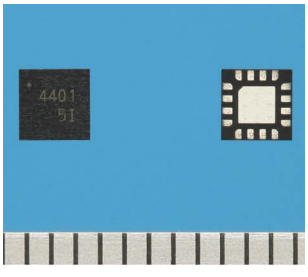
Dissipating 1.1W of total power, it operates from a single 3.3V supply and operates over the industrial-temperature range of −40 to +85°C. The device is available for sampling now, and TI expects volume production in the second quarter of this year. The chip comes in a 48-pin, 7×7-mm QFN package and costs $72.50 (1000).**—by Margery Conner**

▷**Texas Instruments**, www.ti.com.

SiGe power amp targets PHS handsets to WiFi

Toshiba based its new TA4401-CT power amplifier on three cascaded RF stages that target linearity, efficiency, and low power in wireless applications in bands ranging from 1.9 to 2.5 GHz. The targets include PHS (personal-handy-system) handsets, Bluetooth products, and 802.11b/g wireless-LAN applications. In an application such as 802.11g, the typical power draw is a miserly 125 mA. In PHS, a popular, low-cost cellular standard in China, the amplifier offers as much as 23-dBm output power. In shutdown mode, leakage is approximately 1 nA. Available in a 16-pin chip-scale package, the SiGe (silicon-germanium) power amp sells for $1 (sample quantities). Volume production will begin in the second quarter.**—by Maury Wright**

▷**Toshiba Corp**, www.toshiba.com.



The TA4401CT power amplifier draws on three cascaded RF stages for linearity, efficiency, and low power.

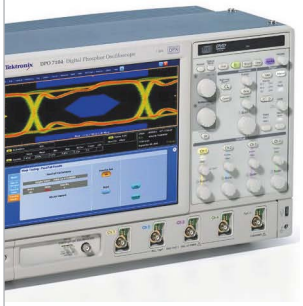
Scopes' array of features, performance, size, and price breaks new ground

To change the landscape in the market, a new digital-oscilloscope family needn't offer the industry's widest bandwidth or highest sampling rate, especially when the new instruments break ground in other ways. Tektronix's DPO 7000 series has 500-MHz, 1-GHz, and 2.5-GHz bandwidths, and two of the units capture 40G samples/sec on one channel. Only much more expensive, greater-than 10-GHz-bandwidth scopes equal that rate—albeit on two channels simultaneously.

Equally revolutionary, especially in a series whose prices start at $14,000, is the 2.5-GHz unit's optional 400M-sample memory depth. Moreover, when you use the scope in the single-channel mode, you can assign all of the memory to the one active channel, but you needn't assign the unused ADCs to that channel. Hence, at 10G samples/sec—four times the scope's −3-dB bandwidth—you can capture an unprecedented 40-msec record (equivalent to two full cycles of the European 50-Hz ac-line frequency). The 4× oversampling is more than adequate for preventing aliasing and is usually acceptable for reconstructing signals at the full 2.5-GHz bandwidth. Interleaving two or all four ADCs reduces the record duration to 20 or 10 msec but can improve the rendition of waveform details—in practice, though not in theory—by increasing the oversampling to 8× with two ADCs interleaved or 16× with four.

In addition, Tek delivers this performance in a package whose approximately 12-in. depth saves precious benchtop space compared with more conventional scopes and sports the industry's largest 12.1-in.-diagonal, touch-sensitive, color LCD screen, which has 1024× 768-pixel resolution.

Another major development in the new series is the fourth generation of FastAcq mode, Tek's proprietary DPX digital-phosphor technology. Unlike earlier implementations, which offered only 1.25G samples/sec, the new version works at sampling rates as high as 40G samples/sec, a 32-times rate increase. The mode radically reduces the scope's "blind time," during which it cannot trigger, and quickly reveals transitory aberrant phenomena by bypassing the conventional time-ordered waveform memory and immediately placing acquired samples in a 3-D color-graded pixel map. The mode is limited to short waveform records, however: 1000 points in the new implementation, increased from 500 points previously. In all three members of the DPO 7000 series, the FastAcq mode captures as many as 250,000 waveforms/sec—more than all but the fastest previous implementation.



The three members of the four-channel DPO 7000 series offer bandwidths of 500 MHz, 1, GHz and 2 GHz; 12.1-in. XGA-resolution screens; very deep memories, which you can make even deeper by purchasing the deep-memory option; and DPX technology, which enables fast capture and color-graded display of 1000-point records.

The new series also marks the introduction of the TekVPI (Versatile Probing Interface) probing system, which enables intelligent bidirectional communication between the scope and the probe and also accommodates older probes of conventional design. In addition to several active voltage probes, the new probe family includes a $2590, 120-MHz-bandwidth current probe that measures 1 mA to 30A (50A peak) without an external amplifier or power supply.

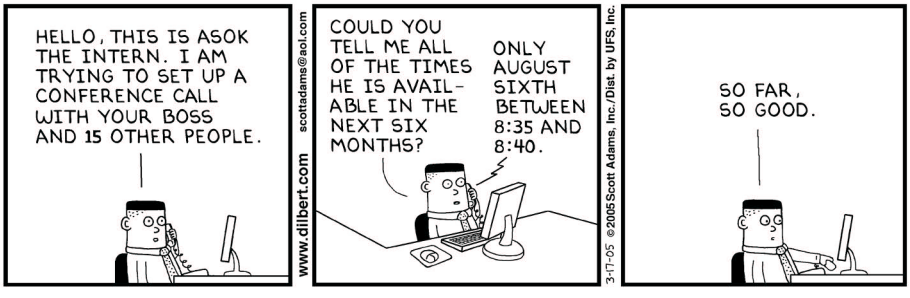
All units have four channels; standard memory is 10M samples/channel in four-channel mode and 40M samples/channel in one-channel mode. Prices for the 500-MHz-bandwidth DPO7054, 1-GHz DPO7104, and 2.5-GHz DPO7254 are $14,000, $17,900, and $24,900, respectively. Maximum sampling rates for the DPO7054 on four channels simultaneously is 2.5G samples/sec on each channel and 10G samples/sec on one channel. The comparable figures for the DPO7104 are 5G and 20G samples/sec, respectively; comparative figures for the DPO7254 are 10G and 40G samples/sec, respectively. Option 2SR doubles the DPO7054's sampling rate for $2000 and the DPO7104's sampling rate for $3500. Deep memory for the DPO7054 and 7104 captures 50M samples/channel on four channels and 200M samples/channel on one channel, and the price is $7500. Comparable figures for the DPO7254 are 100M and 400M samples/channel, respectively; price is $15,000.

All units come with several application-specific analysis-software packages on their hard drives. You can use each package five times at no charge. If you wish to continue using the package, you must purchase and enter an unlock code. All units come with Tek's MyScope software, which allows you to create custom user interfaces. The scopes' prices include continued use of MyScope, which requires no unlock code.

—by Dan Strassberg

▷**Tektronix Inc**, www.tektronix.com.

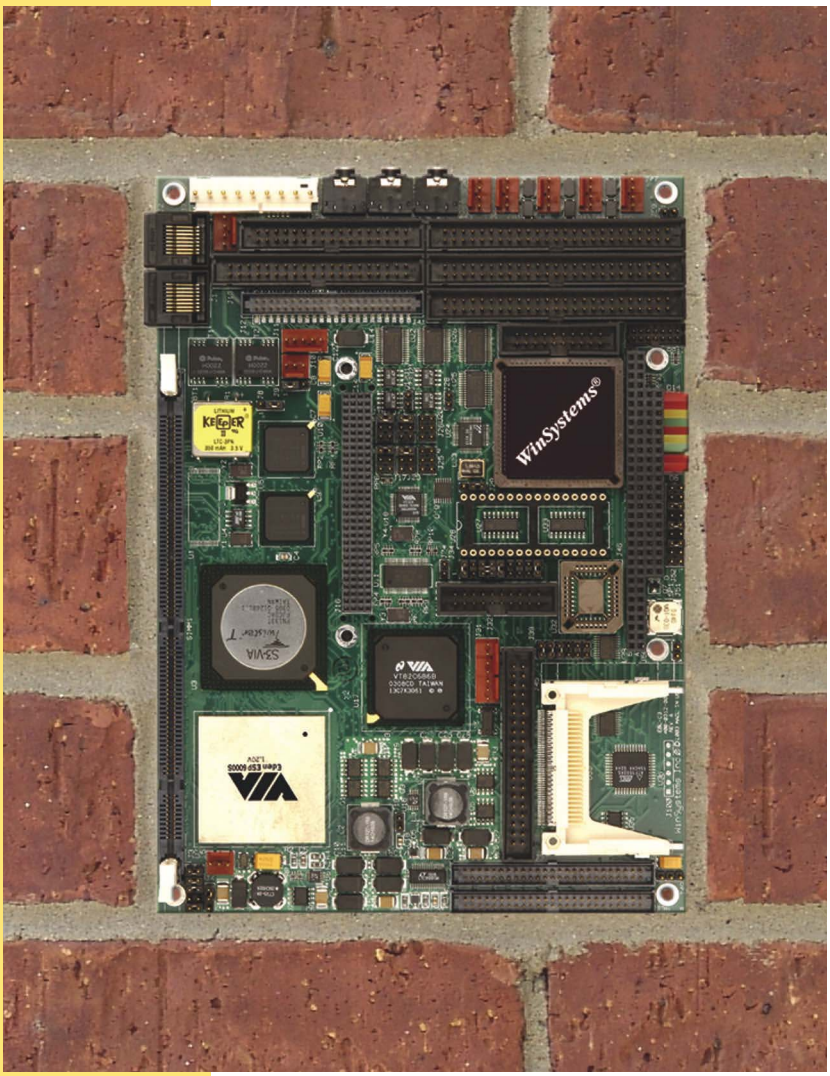
DILBERT *By Scott Adams*



BUILT TO LAST

Fanless EBX 733MHz P3 with COM, dual ENET, USB and Video

- VIA 733MHz or 1GHz C3 CPU
- PC-compatible, supports Windows® XP, CE, Linux and x86 RTOS
- Up to 512MB PC133 SDRAM
- Up 1GB bootable DOC®, 512KB SRAM, or 1MB EPROM
- Type I and II CompactFlash cards supported up to 2GB
- CRT, flat panel, and LVDS
- Two 10/100 Ethernet controllers
- Four USB ports
- Four serial COM ports
- LPT, Kybd, and mouse
- 48 bi-directional I/O lines
- Two EIDE and one floppy disk controller
- AC97 Audio supported
- PC/104 & PC/104-*Plus* expansion
- +5 volt only operation
- EBX size: 5.75" x 8.0" (146 mm x 203 mm)
- -40° to +85°C operation (733MHz)
- Quick Start Developers Kits for Windows® XP, CE, and Linux
- Immediate availability



The EBC-C3 embeds 9 different functions to provide a processor- and I/O-intensive solution. It operates over a -40° to +85°C temperature range without the need of a fan, making it ideal for embedded applications such as robotics, MIL/COTS, transportation, pipeline, and machine control.

It runs Windows® CE, Windows® XP embedded, Linux, and other operating systems as VxWorks and QNX. And its x86-PC software compatibility assures a wide range of tools to aid in your application's program development and checkout.

Call 817-274-7553 or Visit www.winsystems.com

Ask about our 30-day product evaluation!

WinSystems®
715 Stadium Drive • Arlington, Texas 76011
Phone 817-274-7553 • FAX 817-548-1358
E-mail: info@winsystems.com

Microsoft® Windows® Embedded Partner

VDC Platinum Vendor

Platform simplifies video

Texas Instruments' DM6443 and DM6446 processors are the first two devices in the DaVinci family. These devices integrate a 594-MHz video-optimized TI C64x+ DSP core, a 297-MHz ARM926EJ-S processor core, and a video-processing subsystem in a single device to reduce the BOM (bill-of-materials) costs for video applications by as much as 50%. The C64x+ DSP core is an enhancement of the C64x fixed-point DSP and includes an expanded instruction set.

The ARM core incorporates a coprocessor and 15 protection modules. The video-processing subsystem includes a configurable video-processing front-end input for video capture and a configurable video-processing back-end output with imaging-coprocessor display support. Other peripherals include a 10/100-Mbps Ethernet MAC (media-access controller) with a management-data I/O module, USB 2.0 PHY (physical)-layer controller, an audio-serial port, an I^2C bus interface, three UARTs, three PWMs, an asynchronous-external-memory interface, and a synchronous-memory interface for DDR2.

The video-processing front end resides only in the DM6446, and it comprises a CCD controller; a preview engine; a histogram module; the H3A autoexposure, white-balance, and focus module; and a resizer. The previewer real-time processing engine converts RGB Bayer-pattern data from a CMOS sensor or CCD to YUV-422. The histogram and H3A modules provide statistical information on the raw color data. The resizer can perform separate horizontal and vertical resizings of image data ranging from one-quarter- to four-times scale in increments of 256/n, where n is 64 to 1024.

The video-processing back end resides in both devices and comprises an OSD (on-screen-display) engine and a video encoder. The OSD engine can handle two separate video windows and two separate OSD windows. The video encoder employs four analog DACs operating at 54 MHz to support composite NTSC/PAL-video, S-video, and component-video output. It also can provide as much as 24 bits of digital output to RGB888 devices. The digital component can output 8- and 16-bit BT.656 output and CCIR.601 with separate horizontal and vertical synchronizers.

To aid developers, the DaVinci software infrastructure supports development on these devices from low-level operating system drivers to application-level APIs (application-programming interfaces) to enable developers to implement digital video without developing and optimizing the video codecs or programming the DSP. Operating-system support includes MontaVista Linux LSP and open-source Linux. The application frameworks and APIs enable developers to exchange DaVinci components and codecs without modifying the application code. Developers can directly access the DSP and ARM cores.

The DM6443 and DM6446 are available for sampling now at $29.95 and $34.95 (10,000), respectively. The devices are pin- and software-compatible; they are also software-compatible with previous generations of TMS320C64x devices. Software components and tools, including Code Composer Studio and MontaVista (www.mvista.com) GNU tools work with the DM644x devices, and they are available now. Texas Instruments offers video and audio codecs for these devices for free evaluation and licensing. The DV-EVM (evaluation module) is available now for $1995. Codec demos in the evaluation module include H.264, MPEG-4, MPEG-2, AAC+, and G.711.

—by Robert Cravotta

▷**Texas Instruments**, www.ti.com/thedavincieffectpr.

GSM phone on chip targets handsets

Silicon Laboratories recently introduced what it claims is the first fully integrated single-chip phone for GSM (global-system-for-mobile-communication)/GPRS (general-packet-radio-system) handsets. The AeroFone Si4905 integrates the power-management unit, battery interface, charging circuitry, digital baseband, analog baseband, and quadband RF transceiver into a single monolithic CMOS IC. According to Dan Rabinovitsj, the company's vice president, this level of integration drastically reduces the BOM (bill-of-materials) cost for a handset and the R&D resource load for engineers.

The device reduces the component count for a handset from 245 to 58. According to Stan Bruederle, research vice president at Gartner, this component count is lower than that of competing parts and results in higher yield and lower testing time for manufacturers. The device has an integrated digitally controlled crystal oscillator, which eliminates the need for external VCTCXO (voltage-controlled-temperature-compensated-crystal-oscillator) modules that competitive offerings require. The device also integrates 2 Mbits of on-chip SRAM, which allows handset manufacturers to develop GSM phones without external SRAM.

"This chip adds to the growing list of chips that use less space, and that's a big benefit," says Allen Nogee, principal analyst at In-Stat/MDR. "If the electrical specs are what SiLabs claim, it's also notable that SiLabs has achieved such good RF specs from a CMOS RF receiver. Typically, when you combine a receiver in a chip with other components, such as baseband, power management, and video, these other components cause interference." He says that this design does a good job of handling those problems at the RF level. The AeroFone Si4905 is now available for sampling, and the company expects it to enter mass-production in the second quarter of next year.—**by Jeff Berman, Contributing Editor**

▶**Silicon Laboratories**, www.silabs.com.

01.05.06



Cyclone economics

just got more economical.

Cyclone II The lowest-cost FPGAs ever.

Building on the success of the original Cyclone™ family, the 90-nm Cyclone II family gives designers more density, more features, and more speed than ever before, all at a lower price. Cyclone II devices are the lowest-cost FPGAs ever, making them ideal for a wide range of volume-driven applications and creating a compelling alternative to ASICs for high-volume designs.

When you need a company to rely on, Altera delivers. For high performance, more capabilities, fast time-to-market, and a price that will blow you away, contact us today at www.altera.com/cyclone2.

Supported by QUARTUS II

- Densities up to 3.5x the original Cyclone family
- Dedicated DSP circuitry
- Average of 60% faster than the competition
- 90-nm devices shipping in volume

ALTERA®

The Programmable Solutions Company®

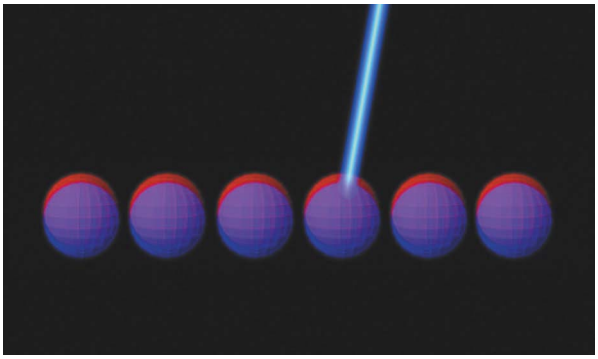
www.altera.com/cyclone2

Copyright © 2005 Altera Corporation. All rights reserved. Altera, The Programmable Solutions Company, the stylized Altera logo, specific device designations, and all other words and logos that are identified as trademarks and/or service marks are, unless noted otherwise, the trademarks and service marks of Altera Corporation in the U.S. and other countries. All other product or service names are the property of their respective holders. Altera products are protected under numerous U.S. and foreign patents and pending applications, mask work rights, and copyrights.

Leading through innovation.

RESEARCH UPDATE

BY MATTHEW MILLER



An artist's conception shows six ions trapped in a state of superposition. The control necessary to achieve such a configuration will play a role in quantum computers and ultrasensitive measurement instruments.

Physicists force six atoms to act like quantum "cats"

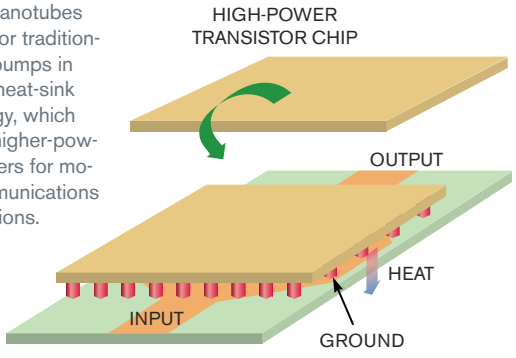
In work with ramifications for quantum computing and cryptography, scientists at NIST (National Institute of Standards and Technology) have coaxed six beryllium ions into a state of entangled superposition, in which their nuclei simultaneously spin both clockwise and counterclockwise. The researchers claim that six is the highest number of atoms that anyone has been able to place into a so-called Schrödinger's cat state. (The name alludes to German physicist Erwin Schrödinger, who famously wrote about a cat that, under the laws of quantum physics, had to be both alive and dead at the same time.) The technique, described in the Dec 1, 2005, issue of *Nature*, could find use not only in quantum computers and encryption schemes, but also in high-precision instruments such, as atomic clocks and interferometers.
▷**National Institute of Standards and Technology**, www.nist.org.

Carbon nanotubes suck heat from high-performance amps

Fujitsu has announced that it will employ carbon nanotubes in heat sinks for high-frequency, high-power amplifiers that will find use in next-generation base stations. Because conventional face-up packaging techniques suffer from amplification-limiting inductance, designers commonly use flip-chip packaging for such amplifiers. However, the metal bumps that connect the amplifiers to their pc boards in the flip-chip approach are proving inadequate for dissipating the heat of high-power transistors, according to the company.

Fujitsu's technology replaces the metal bumps with bundles of vertically oriented carbon nanotubes, grown in a proprietary process using an iron-catalyst coating. The nanotubes offer thermal conductivity of 1400W/(m-K), compared with 400W/(m-K) for copper. According to Fujitsu, the approach yields heat-dissipation levels equivalent to face-up configurations but halves inductance, which in turn yields at least a 2-dB increase in amplification at frequencies of 5 GHz or greater.
▷**Fujitsu**, www.fujitsu.com.

Carbon nanotubes stand in for traditional metal bumps in Fujitsu's heat-sink technology, which enables higher-power amplifiers for mobile-communications base stations.



FLIP-CHIP HIGH-POWER AMPLIFIER
USING CARBON-NANOTUBE BUMPS

Chip electrically controls the speed of light

Researchers at IBM have fabricated the first optical chip that electrically controls the speed of light. The chip works by electrically altering the effective index of the refraction of an integrated photonic-crystal waveguide. The component could one day enable tunable optical delay-line chips, optical buffers, high-extinction optical switches, and highly efficient wavelength converters. The device, along with other components, could also eliminate the telecom industry's reliance on bulky and costly optical-to-electrical and electrical-to-optical converters. The chip can variably slow light by a factor of 300, under active control by a signal that consumes less than 2W and changes in less than 100 nsec. IBM built the chip on silicon-on-insulator CMOS.

The active element is a 250-micron-long photonic-crystal waveguide formed with a nanoscale version of micromachining that perforated a 223-nm-thick membrane with 109-nm-diameter holes spaced at a 437-nm pitch. As a result, the waveguide slows light passing through it in a 20-nm bandwidth at the communications wavelength of 1620 nm. For more information, including an animated demonstration, go to http://domino.research.ibm.com/comm/pr.nsf/pages/news.20051103_photonics.html. For an animation of how the technique works, go to www.research.ibm.com/photonics/animation/slowlight.html.
▶**IBM Corp**, www.ibm.com.

01.05.06

8-bit Microcontrollers

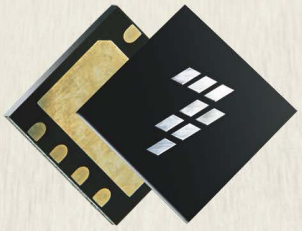
Freescale Semiconductor, a global leader in 8-bit microcontrollers, is committed to providing the most comprehensive portfolio that delivers market-driven features at competitive pricing. All backed by our industry-leading CodeWarrior™ Development Studio with Processor Expert™ technology, affordable hardware development tools and support services that make your design effort easier.

Our 9S08QG Family is a great example of our 8-bit leadership. This tightly integrated 8-bit solution combines levels of performance, packaging and low-power consumption that redefine the low end. Making it ideal for a variety of applications like home appliances, remote control, lighting and security systems.

Get higher resolution with our 8-channel, 10-bit ADC. Communicate with SCI, SPI and I^2C. Choose from 4K and 8K reprogrammable Flash options. Plus these devices offer an on-chip, in-circuit emulator (ICE) and background debug module to reduce development time and cost.

Test drive our support tools via our virtual lab capability or get started now with our 9S08QG8 demo board, priced at $50* (US). You get a fully functional board, powered over the USB cable, eliminating the need for external power supplies.

We offer the products, service and support to help you add value and get to market quickly and efficiently.



MC9S08QG
8-pin DFN
4mm x 4mm

It's how you get higher value at the low end.



$50* demo board at freescale.com/low8

freescale™ semiconductor

Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners. This product incorporates Super Flash technology licensed from SST. *All quoted pricing is MSRP. ©Freescale Semiconductor, Inc. 2005.

GLOBAL DESIGNER

EDA-tool pairing tackles ESL "model gap"

As an enabling technology for the wider implementation of system-level design, Tenison and Spiratech have created a closely integrated pairing of their respective VTOC and Cohesive EDA products. Tenison's software converts models of circuit blocks between levels of abstraction in a system-level design environment. In system-level design, Tenison says, you need to design with mixed tools and at multiple levels of abstraction. The company says that in a typical design, 80% of IP (intellectual property) is in RTL. Meanwhile, logic errors are still the dominant cause of design failure. You don't rewrite the RTL, and trying to write a model of it is a highly error-prone process.

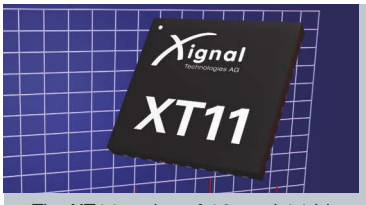
VTOC lets you move models between levels of abstraction. Tenison adds the Spiratech software's ability to automatically generate "transactors," high-performance transaction-level interfaces to those models. Cohesive allows the user to formally specify an interface using a specialized language that then compiles to generate the transactor. Once the user has performed the formal specification, the software can create a bridge between any two levels of abstraction. Users can verify conformance to a protocol by entering a description of the protocol. So, VTOC converts RTL to SystemC, and Cohesive creates a transactional interface to it. Tenison Chief Technology Officer Jeremy Bennett says, "The ability to connect between models at different levels of abstraction is a cornerstone of any practical ESL solution," and Spiratech Chief Executive Officer Simon Calder says, "There are no excuses left for not adopting an ESL methodology; this tool combination greatly eases the connection of transaction-level models to the design-and-verification tool flow."

In a parallel announcement, Tenison has also produced a version of the VTOC offering closely integrated with the ARM (www.arm.com) RealView development environment to facilitate system-level design of complex ARM-based projects.

—by Graham Prophet, *EDN Europe*

▷**Tenison EDA**, www.tenison.com.

▷**Spiratech**, www.spiratech.com.



The XT11 series of 12- and 14-bit, self-clocking ADCs use 70 mW while clocking at 200M to 40M samples/sec.

01.05.06

ADCs use less than 100 mW at 40 MHz and 14 bits

"The lowest power delta-sigma ADCs available anywhere" is the claim of fabless-semiconductor vendor Xignal Technologies. It based its product concept on an architecture it calls continuous-time delta-sigma. With it, designs can achieve resolutions of 12 bits and higher at power levels less than half those of competing ADCs, says Xignal's marketing director, Mark Holdaway. A sigma-delta converter is a control loop in which a comparator samples the output of an integrator to yield a pulse-density output waveform. Integral to that loop is a filter, which, in a conventional sigma-delta design, is a discrete-time arrangement that depends on switched-capacitor techniques. Xignal's design replaces this technique with a continuous-time digital filter, taking switches outside the signal path. The approach simplifies the device's analog circuitry, eliminating the need for several functional blocks, such as an input buffer that previously dealt with sampling glitches.

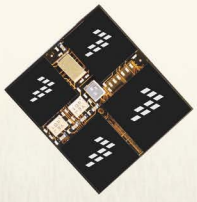
The design integrates high-stability inductors and capacitors and a PLL that delivers clocking with very low phase noise. The architecture makes the ADC compatible with the scaling benefits of small-geometry CMOS, further assisting the power benefits from reducing the power-hungry analog blocks in the design. Because the digital filter is outside the conversion loop of the ADC, the design also needs no separate antialiasing filter. Using the IEEE's formula for figure of merit relating power per bit of conversion resolution and conversion frequency, Holdaway says, the CT sigma-delta achieves a figure double that of previous ADCs.

Hence, the XT11 series of 12- and 14-bit, self-clocking ADCs use 70 mW while clocking at 20M to 40M samples/sec and are simple to drive, needing no differential input buffer. The continous-time loop filter can handle "beyond-the-rails" inputs, enabling the XT11200 and 11400 to accept ±4V inputs while operating from a 1.2V supply. The continuous-time sigma-delta modulator is a third-order design, and the chip also integrates a tunable loop filter plus a digital lowpass filter. The chips can sample the entire bandwidth to the Nyquist limit—20 MHz for a 40-MHz clock—with virtually no wasted bandwidth. SNR is 76 dB, and THD is −82 dB for the 14-bit part; the corresponding figures for the 12-bit converter are 71 and −78 dB.

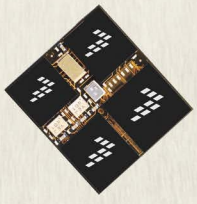
"The architecture has found use in single-sample-rate applications, such as wireless base stations," says Holdaway. Because analog elements determine bandwidth, a given implementation has restricted operating frequency. Xignal says that this limitation implies operation over a range of frequencies, rather than a fixed frequency of operation. The on-chip, low-phase-noise clock requires only a low-cost crystal. The converters will sell for $9.95 or $18 (1000).**—by Graham Prophet, *EDN Europe***

▶**Xignal**, www.xignal.com/xt11.

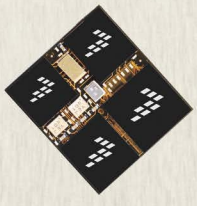
3G Solutions



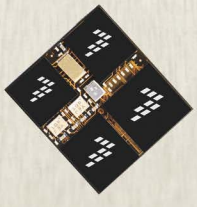
It’s the freedom of an open platform.



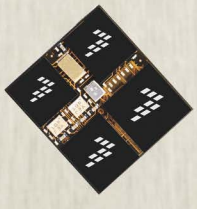
It’s the freedom to miniaturize.



It’s the freedom to cut costs.



It’s the freedom to differentiate.



It’s freedom for 3G.

MXC 3G Phone Platform
19mm x 21mm

A 3G phone the size of a postage stamp? Visit freescale.com/3G

freescale™ semiconductor

Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners. ©Freescale Semiconductor, Inc. 2005.



BY HOWARD JOHNSON, PhD

Half-measures

Perky little Miss Flynn, my fifth-grade physical-education teacher, used to admonish her flock: "Never go in for half-measures; always try your hardest." I like to test rules, so as life progressed, I tried drinking as much as possible and driving as fast as I dared. I discovered that her rule did not apply to those situations. Digital engineers know a circuit in which half-measures are not only acceptable, but also necessary (**Figure 1**).

When you close switch A, a half-sized step emanates from the source. It propagates across the pc-board trace (the thick blue line) toward B. When the half-step slams into B, it finds no load to absorb any power, so the half-step bounces back, returning to the source. At the source, resistor R_I terminates the reflected half-step. After that time, the outbound and reflected currents perfectly cancel at all points, bringing the structure to a stable, fully charged condition. The whole scenario takes precisely one round-trip time.

Do you suppose the outbound step must be *exactly* half-sized, or will any other size of waveform do the trick? If you change the source-termination resistor R_I to a value other than Z_0, will the circuit work in a new way?

I say no. The proof involves the principle of conservation of energy—something that Miss Flynn may not appreciate, but in the world of physics, a good energy-balance equation easily sums up the operation of a complicated system without bogging you down in details.

Begin by calculating the total energy supplied to the transmission line. With the circuit in a state of perfect rest, assume the source conveys a step voltage into the transmission line with amplitude V_i. The characteristic impedance of a pc-board trace, in the range of frequencies and geometries that high-speed digital work uses, nearly approximates a pure resistance. Until the first reflection returns from the far end, the source thinks it's driving a resistive load having a value of Z_0. The power, P_i, delivered to the transmission line under these conditions equals V_i^2/Z_0. Over time equal to twice the line delay, or $2T$, the total energy, E_i, that the source delivers equals:

$$E_i=2TV_i^2/Z_0.$$

At the end of one full round-trip cycle, if the line achieves stasis fully charged to voltage V_T at all points, with zero current, then all of the energy supplied during the period $2T$ must be stored in the distributed capacitance, C, of the transmission line. This stored energy equals $(1/2)CV_T^2$. The tricky part of this argument is knowing how to calculate the capacitance, C, which is just the line delay, T, divided by its characteristic impedance, Z_0 (**Reference 1**). Making that substitution for C produces an expression for the total energy stored at the conclusion of a successful cycle:

$$E_S=(1/2)(T/Z_0)V_T^2=(1/2)TV_T^2/Z_0.$$

Equating the stored energy, E_S, to the supplied energy, E_i, reveals that the initial step amplitude, V_i, must equal half of V_T. A larger initial step amplitude supplies too much energy; it rattles about, slowly dissipating. A smaller step supplies too little, taking multiple round trips to finish the job. Perfect operation of this circuit *requires a precise half-measure*.EDN

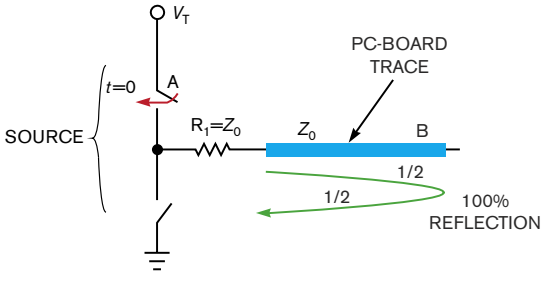


Figure 1 A half-sized step slams into B, bounces, and returns to the source.

REFERENCE

1 Johnson, Howard, and Martin Graham, *High-Speed Digital Design: A Handbook of Black Magic*, Prentice Hall, April 1993, pg 149, equation 4.40.

MORE AT EDN.COM

Go to www.edn.com/060105hj and click on Feedback Loop to post a comment on this column.

Howard Johnson, PhD, of Signal Consulting, frequently conducts technical workshops for digital engineers at Oxford University and other sites worldwide. Visit his Web site at www.sigcon.com or e-mail him at howie03@sigcon.com.

Intersil Digital Potentiometers

High Performance Analog

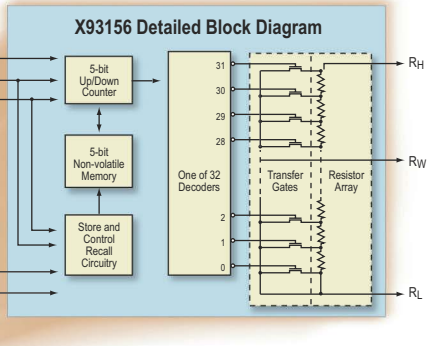
Huge Digital Control in a Tiny Package



Intersil's unleashes the X93154/55/56, the world's smallest and lowest cost Non-Volatile Digital Potentiometer.

The X93154, X93155 and X93156 addresses new market needs for high volume and space constrained applications such as portable or personal communications devices. The integration of non-volatile EEPROM for the wiper position provides design advantages including lower programming current and the elimination of additional high voltage supplies required by one-time programmable products.

All this functionality in tiny 2mm x 2.5mm TDFN package





Features

- 3-wire up/down interface
- 32 wiper tap points. Wiper position stored in non-volatile memory and recalled on power-up
- Low power CMOS, with V_{CC} of 2.7V to 5.5V, active current of 250µA max, and standby current of 1µA max
- High reliability with endurance 200,000 data changes per bit and register data retention of 100 years
- Available in 8-lead MSOP and TDFN packages
- Pb-free and RoHS compliant packaging available

Key Parameters

Description	Conditions	MIN	TYP	MAX	Unit
Supply Voltage	X93154	2.7	3	3.3	V
	X93155	4.5	5	5.5	V
	X93156	2.7	-	5.5	V
End-to-end Resistence		35	50	65	kΩ
R_H, R_L Terminal Voltages		0	-	V_{CC}	V
Power Rating	R_{TOTAL} = 50 KΩ	-	-	1	Mw
Noise	Ref: 1kHz	-	-120	-	dBV
Wiper Resistance	X93156	-	-	1100	Ω
Wiper Current		-	-	0.6	mA
Resolution		-	3	-	%
Temperature (Industrial)		-40°C	-	+85°C	C

Datasheet, free samples, and more information available at **www.intersil.com/edn**

Intersil – Amplify your performance with advanced signal processing.

©2005 Intersil Americas Inc. All rights reserved. The following are trademarks or services marks owned by Intersil Corporation or one of its subsidiaries, and may be registered in the USA and/or other countries: Intersil (and design) and i (and design).

intersil®
HIGH PERFORMANCE ANALOG

Valuing uncertainty



DANIEL VASCONCELLOS

As a junior member of a technical staff, I was testing and characterizing how well the automatic-gain-control and target-acquisition algorithms operated with a new visible-light camera sensor. The vision system needed to be able to distinguish and identify a subpixel target within a field of stars from an exoatmospheric position. We were unfamiliar with the sensitivity and idiosyncrasies of the camera-sensor system, but because the vision system would be deployed in low Earth orbit, we could not test the vision system and the various algorithms in field conditions.

An important function of the automatic-gain-control algorithm was to dynamically adjust the sensitivity of the camera sensor to avoid blindness, either from too little or too much light entering the sensor. The intensity of the light from the object we would be searching for in the low-orbit sky would range from faint to bright over the course of a few seconds. The automatic-gain-control algorithm would allow the system to scale the sensor's sensitivity so that the camera would register the object's light signature at low intensity and prevent the increasing intensity from oversaturating the sensor.

At first, the task of setting up the lab testbench to characterize the camera system and automatic-gain-control algorithm seemed fairly straightforward. My lab partner and I began with coarse adjustments to the light level to characterize how the algorithm affected the data for the camera's entire FOV (field of view). As we progressed through the testing, we refined the light source to affect a smaller and smaller portion of the camera's FOV. Things were moving along well until we tried to generate a light source that could be contained within a single pixel.

Generating a light source that we could confirm excited only a single pixel on the camera sensor proved to be quite a challenge. The light source we were using generated a signal larger than a pixel. We were eventually able to approximate a single pixel signal by blocking the light source with cardboard that had a pinhole in it. The process of trying to create and verify a single pixel signal revealed an important unknown and undesirable behavior of the vision system. We reported the condition, and the project engineer expanded our task to understand and develop a correction for the problem.

The instructions for my lab partner and me were to characterize the camera system and to make sure the automatic-gain-control algorithm appropriately adjusted the camera's sensitivity. *How* to test the system remained unspecified. The system engineer had not expected us to try to simulate a single pixel signal. Because we were not influenced by his assumptions about the camera system, we uncovered an anomalous condition in the lab that would have caused the vision system to fail when it was deployed. Senior engineers are expected to be able to begin work with systems that have little concrete definition and much uncertainty.

Uncertainty in business and production environments is undesirable; it can lead to variable results that negatively impact the success of building a product or delivering a service. A key defining element of engineering is to be able to create systems that can deliver consistent, repeatable, and reliable behavior despite uncertainty and variability over some range of environmental conditions. Dealing with uncertainty is fundamental to being an engineer, and there is usually a positive correlation between the seniority of an engineer and the amount of uncertainty he needs to deal with in his job. It is important to allow some uncertainty to exist in assignments for even the most junior engineers, as it can be a source of growth for them—and it might save a project from failure.

Because of my experience in that lab, I learned always to allow some uncertainty in assignments to junior engineers; it helps them learn and stretch their skills and can help the project in unexpected ways. EDN

BREAKTHROUGH 7-PIN MOSFET PACKAGE ENABLES 160A IN A D²PAK

Lower $R_{DS(on)}$ Ratings of Trench Technology with Higher Current for Automotive



Part Number	Package	VDS	$R_{DS(on)}$ (mΩ)	ID, max. (A)	R_{th} (C/W)	Typ RDS(on) Temp Coeff.	Gate	Qual Level
IRF2804S-7P	D²Pak-7	40V	1.6	160*	0.50˚	1.80	Std	Q101
IRF3805S-7P	D²Pak-7	55V	2.6	160*	0.50˚	2.10	Std	Q101
IRF1405ZS-7P	D²Pak-7	55V	4.9	120*	0.65˚	2.10	Std	Q101

* Package Limited

International Rectifier's innovative, Q101 qualified, 7-pin D²Pak MOSFETs address the industry problem of the limited current carrying capability of plastic discrete packages. The new 7-pin package offers the lower $R_{DS(on)}$ ratings of trench technology with the higher current required for automotive applications such as electronic power steering (EPS).

Seven-pins reduce board level lead temperature with a greater reliability of solder joints at double the current handling capability of a standard 3-lead package. Extra leads also allow a larger leadframe T-post for additional wirebond area capability and the added benefit of reduced die free package resistance.

FEATURES

- 160A continuous current capability (maximum junction temperature of 175˚C)
- Lowest $R_{DS(on)}$ available in a D²Pak footprint
- Low temperature coefficient of on-resistance
- Avalanche capability comparable to industry leading planar technologies

Contact your local IR sales representative to see how the breakthrough 7-pin, 160A Q101-Qualified MOSFET in D²Pak can help speed your designs.

for more information call 1.800.981.8699 or visit us at
www.irf.com/auto

International
IOR Rectifier
THE POWER MANAGEMENT LEADER

AUTOMATICALLY-GENERATED CODE FLYING AT MACH 9.8.



THAT'S MODEL-BASED DESIGN.

When NASA made history by launching the X-43A, automatically-generated flight code was at the controls for the vehicle's propulsion and stability systems. Engineers developed the autopilot within a radically reduced timeframe using Model-Based Design and Simulink. To learn more, go to mathworks.com/mbd

MATLAB® & SIMULINK®

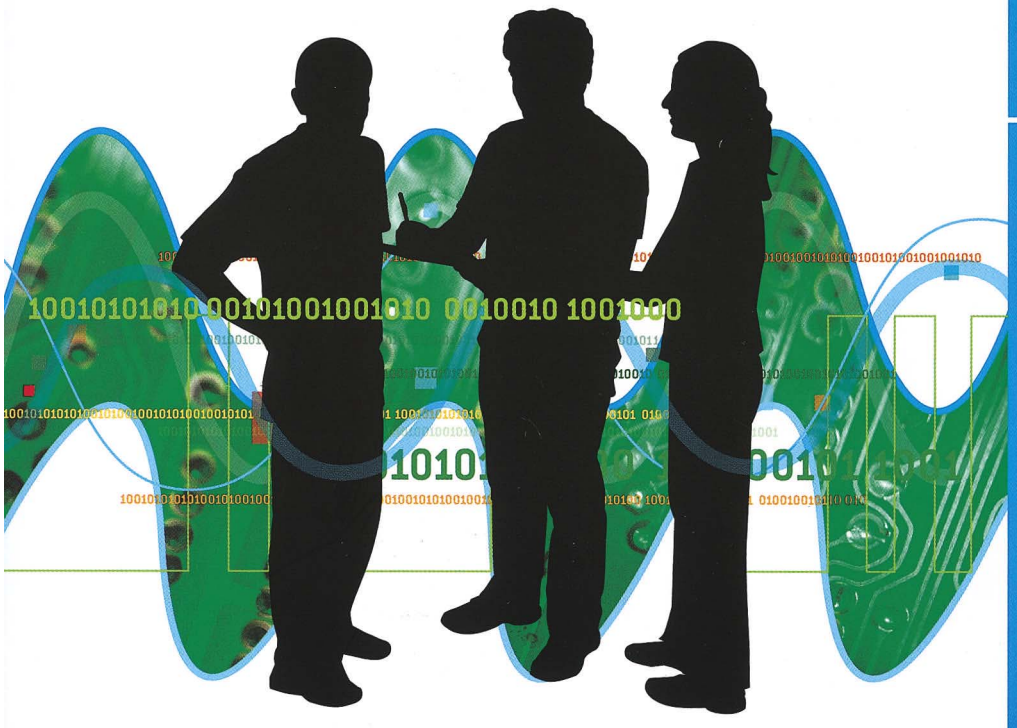
The MathWorks

Accelerating the pace of engineering and science

©2006 THE MATHWORKS, INC.

TI | Developer Conference

February 28-March 2, 2006 • Dallas, TX



SEE THE FUTURE

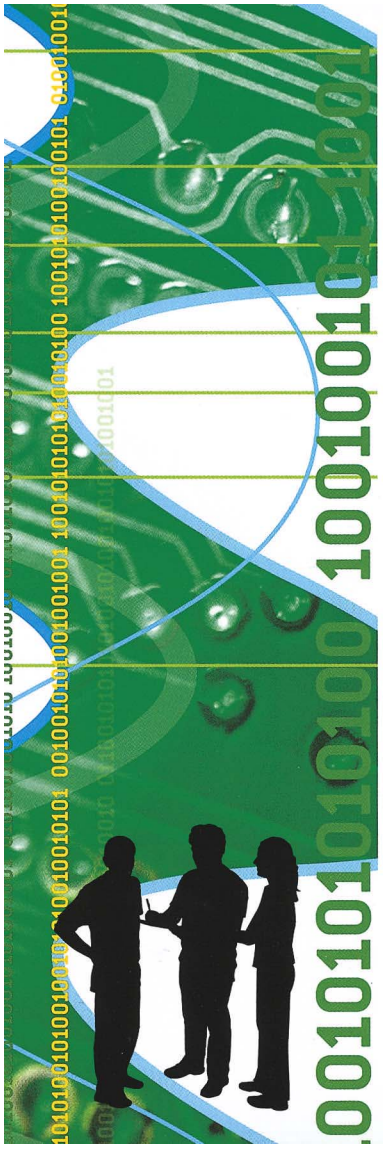
CREATE YOUR OWN

Featured Applications Include:

- Audio
- Communications
- Control
- Video
- And More ...

Technology for Innovators™

Texas Instruments



TI Developer Conference

February 28-March 2, 2006 • Dallas, TX

Register Today!

The TI Developer Conference offers you three days of hands-on technical learning and answers to your design questions from signal processing experts throughout the high-performance analog (HPA), digital signal processing (DSP) and micro-controller industries. Build your expertise on next-generation design through:

- 100+ system-focused sessions
- Hands-on workshops
- Networking with industry experts
- Exhibit hall and Technology Playroom

Register by January 30, 2006 and save $500

www.ti.com/tidc2006pc

SEE THE FUTURE

CREATE YOUR OWN

Technology for Innovators and the red/black banner are trademarks of Texas Instruments.
© Texas Instruments 2005.

TECHNICAL TRACKS

- Audio
- Communications
- Control
- Education
- Systems
- Tools
- Video/Imaging

SPRT376

BY JEFFREY LIES, TAMARA PAPALIAS, AND MIKE WONG • INTERSIL CORP

Choosing high-speed amplifiers for noise-sensitive applications

VOLTAGE FEEDBACK, CURRENT FEEDBACK, BIPOLAR, CMOS—ALL HAVE ADVANTAGES AND DRAWBACKS. HERE'S A ROAD MAP FOR PICKING THE BEST TYPE FOR YOUR APPLICATION.

High-speed amplifiers have broken the gigahertz barrier, making them an attractive choice in many applications. Fundamental differences exist in the types of amplifiers on the market. The two most critical characteristics involve process (bipolar or CMOS) and feedback (current or voltage). Both current- and voltage-feedback amplifiers are popular for high-speed applications. This article focuses on noise characteristics, as well as the strengths and limitations of each type. An understanding of the differences in circuit topology, along with basic noise and distortion characteristics, is crucial for optimal product selection.

VFAs (voltage-feedback amplifiers) are the most common op-amp topology. This topology has three stages: a differential-input stage, a gain/level-shift stage, and an output stage. **Figure 1** presents a simplified schematic of the EL5157, a popular VFA.

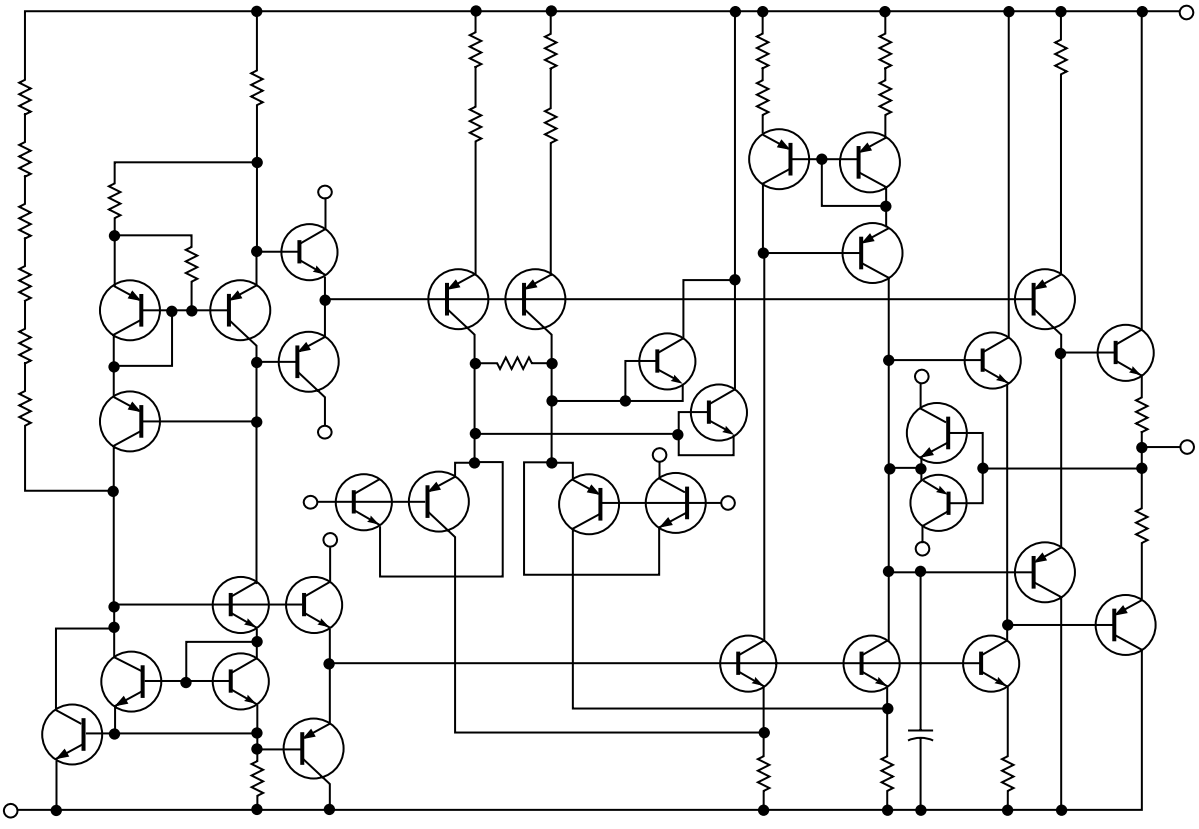


Figure 1 The EL5157 is an example of a voltage-feedback-amplifier topology.

The input stage is an NPN differential pair in parallel with a PNP pair. The second stage consists of a pullup current source. Any difference (signal or error) in the currents of the signal-path transistors appears across the output impedance of the current source at the high-impedance node. The output stage buffers the high-impedance node to the output.

CFA TOPOLOGY

CFAs (current-feedback amplifiers) have a different input structure. The input stage has a unity-gain buffer between its inverting and noninverting inputs that gives the CFA topology some distinct advantages. CFAs' popularity lagged voltage-feedback designs until the emergence of fully complementary bipolar processes. Fortunately, these processes are widely available today, so CFAs can exploit the current switching, which is faster than bipolar circuits' voltage switching.

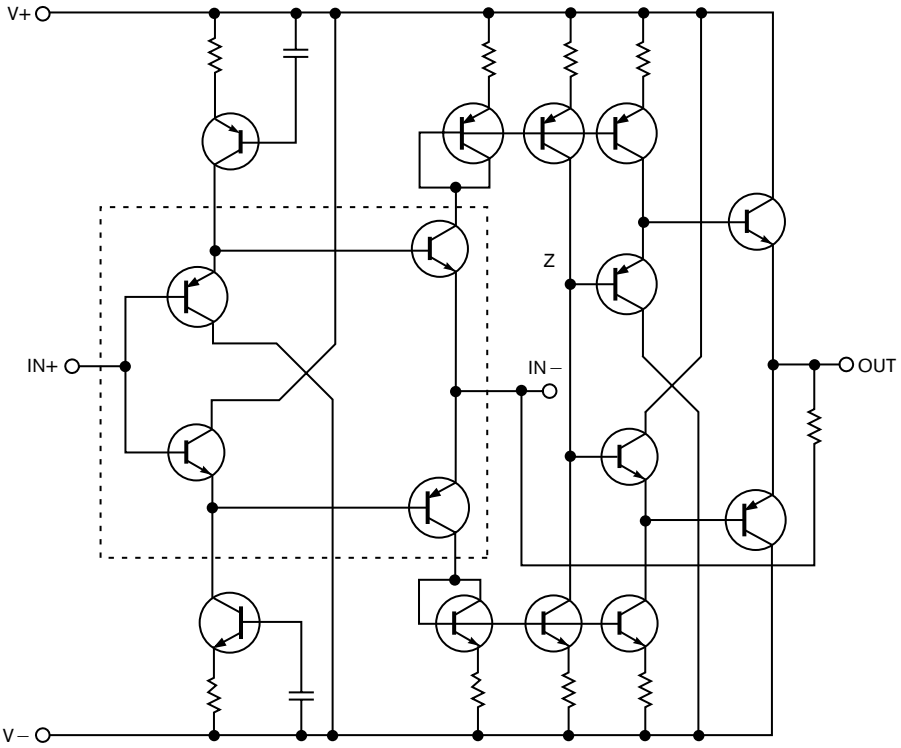


Figure 2 In this current-feedback amplifier, the noninverting input has high impedance and is buffered to the inverting input.

In **Figure 2**, the noninverting input has high impedance and is buffered to the inverting input (see dashed box). The input impedance of the inverting input is very low, and its signal reaches the high-impedance node through current mirrors. The high-impedance node, Z, is buffered to the output.

A higher level look at the CFA structure highlights its advantages (**Figure 3**). Any voltage difference across feedback resistor R_F creates an error current into the inverting input. Because the impedance at the inverting input is low, this feedback is a current. Another name for a CFA is a transimpedance amplifier, because any change in the inverting-input current causes an output-voltage change. The inverting input can source and sink high transient currents, which bias current does not limit. The current mirrors supply current on demand from the power supply to the high-impedance node, giving CFAs high slew rates. A unity-gain buffer completes the circuit, driving the output to the voltage necessary to minimize the feedback error current.

The value of R_F determines the amount of current fed back to the inverting input. Therefore, when you vary the gain of a

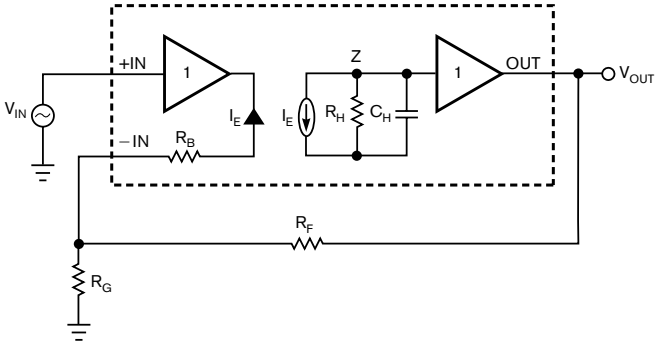


Figure 3 A current-feedback amplifier is also called a transimpedance amplifier because any change in the inverting-input current causes an output-voltage change.

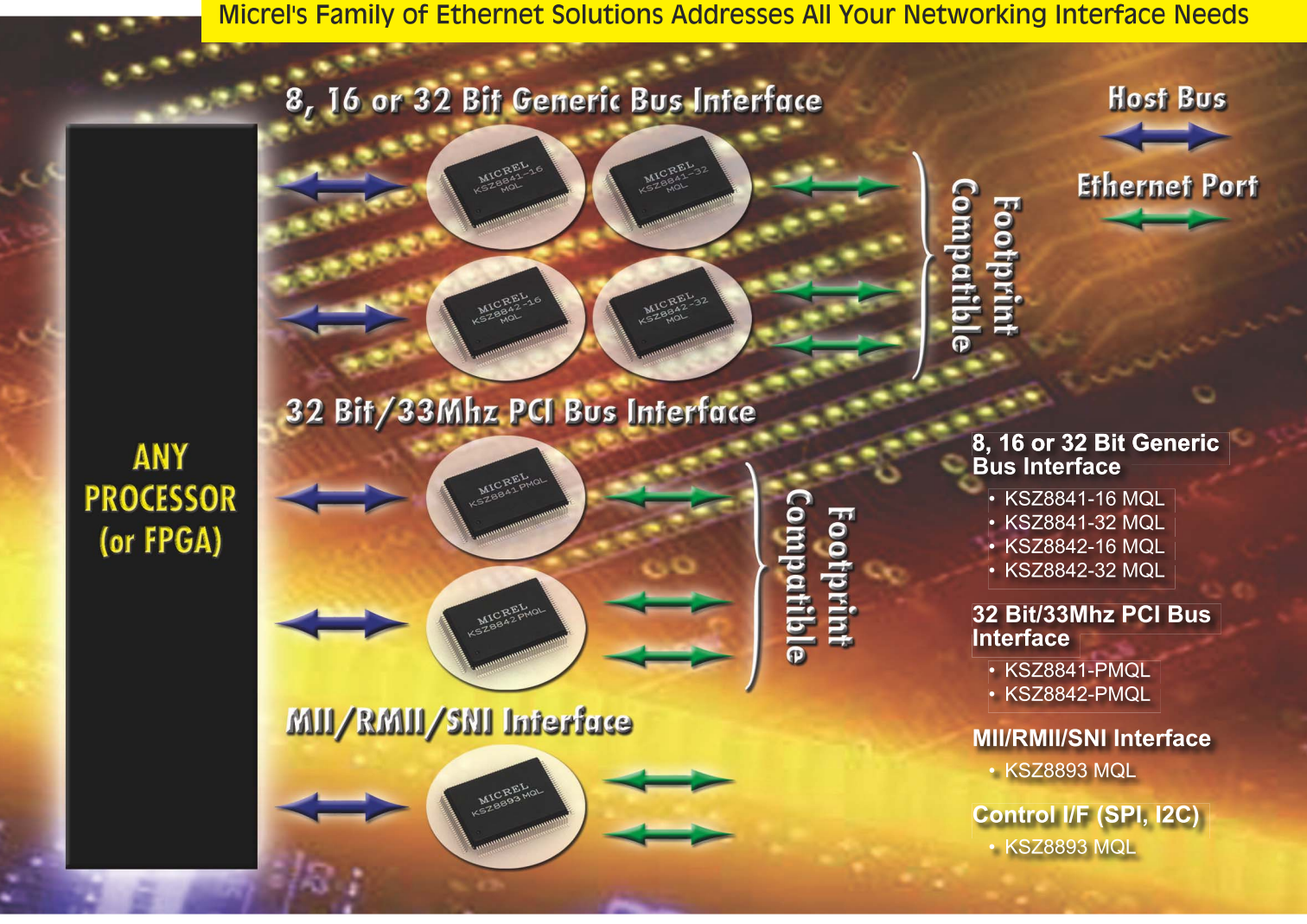
TABLE 1 DOMINANT TYPES OF NOISE IN AN OPERATIONAL AMPLIFIER

Type of noise	Calculation
Thermal (Johnson) noise	$V_{JN} = \sqrt{(4KTR\Delta f)}$
Shot noise	$I_{SN} = \sqrt{(2qI_{DC}\Delta f)}$
Flicker (1/f) noise	$I_{FN} = \sqrt{(k_d I_{DC}^{\ a} f^{-b}\Delta f)}$

Notes:
K = Boltzmann's constant (1.38×10^{-23} J/K).
T = absolute temperature in Kelvin (0°C = 273 Kelvin).
R = resistance of component/device.
I_{DC} = dc current.
q = charge on an electron (1.6×10^{-19} C).
Δf = system bandwidth.
f = center frequency of operation.
k_d = device constant (varies by orders of magnitude; even on one wafer, MOS tends to be higher than a bipolar-junction transistor).
a = fabrication constant (ranges from 0.5 to 2).
b = constant (approximately = 1).

Micrel Ethernet Solutions:
We've Got Your Processor Covered

Micrel's Family of Ethernet Solutions Addresses All Your Networking Interface Needs



The road to network connectivity is never smooth but Micrel has you covered. Whether you need networking via an 8, 16 or 32-bit generic-bus, PCI-bus, MII, RMII, or SNI host interfaces, Micrel has the answer in easy to install single and dual-port Ethernet solutions. The devices address the growing need for streamlined networking connectivity in IP-Set Top Boxes, VoIP phones, Network Printers, Industrial Controls and networked Game Console applications, to name but a few. The dual port devices have the lowest latency (sub 310nS) in the industry and are ideal for daisy-chaining applications, or simply as two port switches to connect to voice, video and data.

All of the ICs incorporate HP Auto-MDIX to take the guesswork out of whether your device is connected using straight or cross-over cables. In addition, Micrel's LinkMD™ cable diagnostics function not only determines the length of the cable and the distance to fault, but also diagnoses common cabling faults such as open and short circuits. These features reduce the need for costly customer calls and IT service requests. Along with Micrel's trademark high reliability, outstanding performance, and low power consumption, the KSZ88xx family offers ideal solutions for applications that require compact, cost effective, RoHS compliant networking connections.

For more information, contact your local Micrel sales representative or visit us at www.micrel.com/ad/ksz88xx.
Literature: 1 (408) 435-2452 • Information: 1 (408) 944-0800

MICREL®
Innovation Through Technology™

www.micrel.com

© 2005 Micrel, Inc. All rights reserved. Micrel is a registered trademark and LinkMD is a trademark of Micrel, Inc.

CFA, you should adjust the value of R_G. Also, although VFAs exhibit a gain-bandwidth trade-off, CFA bandwidth is inversely proportional to the value of R_F.

OP-AMP-NOISE CALCULATIONS

Figure 4 presents a classic noise model of an operational amplifier with feedback. The **figure** shows all of the possible noise sources, including thermal (Johnson) noise voltages for the external feedback and gain resistors. Whereas the resistor-noise sources do not change versus frequency, the voltage- and current-noise sources in association with the op amp are frequency-dependent. Therefore, op-amp data sheets provide plots of input voltage and current noise.

The two main components of noise within op amps are flicker and white noise. Flicker noise, also called 1/f noise because its contribution is inversely proportional to frequency, dominates at low frequencies (less than a few megahertz for CMOS and less than a few kilohertz for bipolar designs). White noise includes contributions of shot noise from bias currents and thermal noise from resistances in devices and other circuit structures. With its flat amplitude characteristic with respect to frequency, white noise dominates at medium and high frequencies. **Table 1** lists the types of noise and their mathematical equivalents.

By convention, noise quantities are input-referred. That is, the presented value is the amount that would appear at the input to cause the resultant noise at the circuit output. For example, if a noise source exists at an amplifier's output, you divide it by the closed-loop gain to refer it to the input. Referring all of the noise to the same node simplifies comparing and combining the influence of various noise contributions.

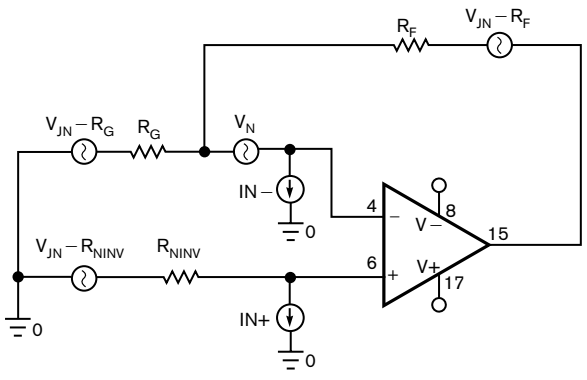


Figure 4 This classic noise model of an op amp with feedback shows all of the possible noise sources, including thermal (Johnson) noise voltages for the external feedback and gain resistors.

For **Figure 4**'s amplifier example, you can calculate the noise sources, as **Table 2** shows. To facilitate comparison, all noise sources appear as voltages. The third column identifies the voltage gain that each noise source experiences.

Noise is a random quantity. A noise source's average voltage

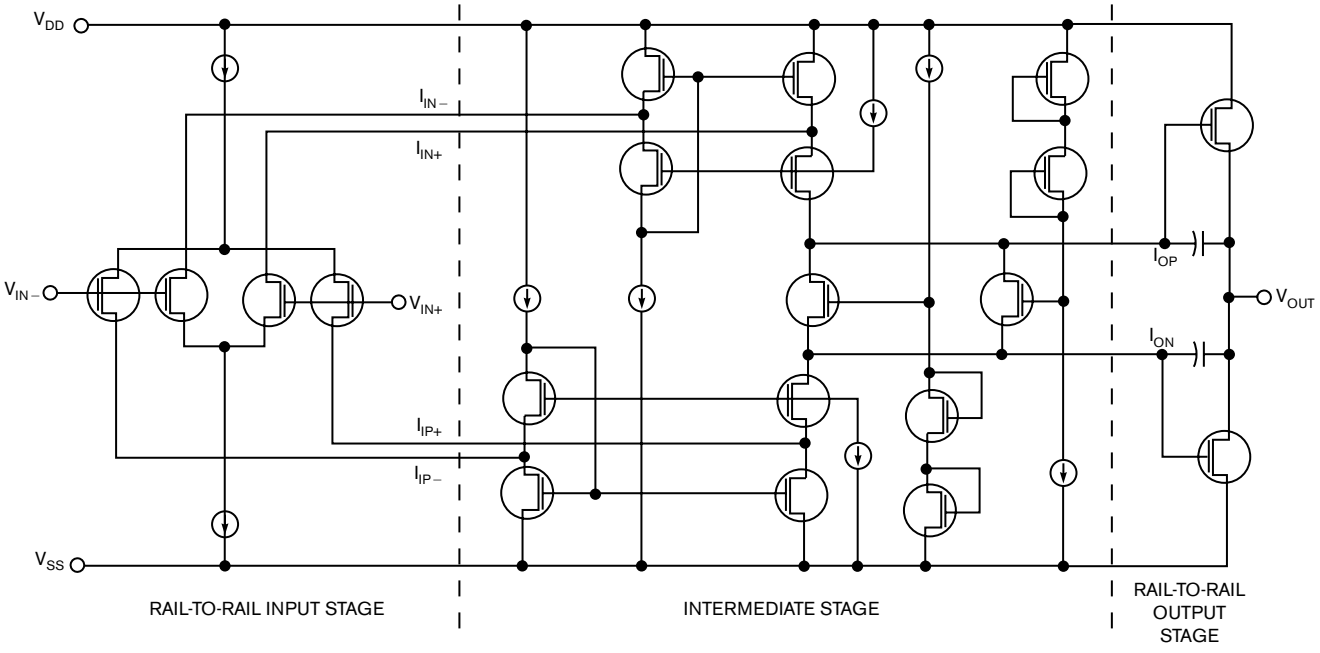
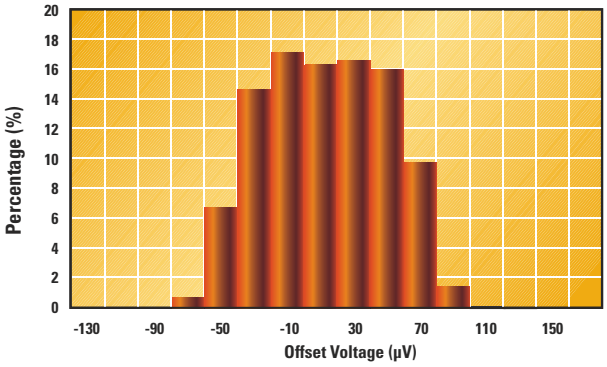


Figure 5 In this simplified CMOS op amp, both inputs connect to MOSFET gates, which allow virtually zero current flow. Thus, only voltage determines the output signal, explaining the amplifier's low level of input-current noise.

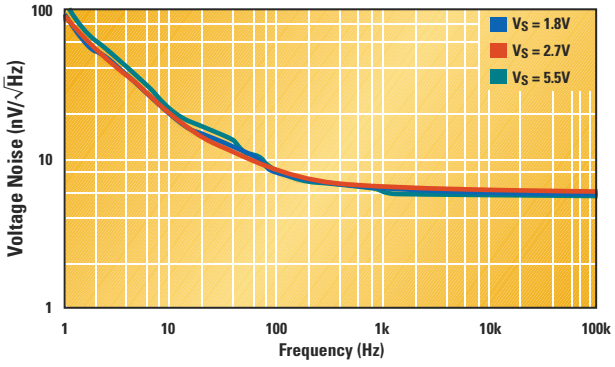
Precision, Efficiency, Low Noise & Low I_{BIAS}

National's Advanced VIP50 BiCMOS Process Does It All

LMP7711 Offset Voltage Distribution



LMP7711 Input Voltage Noise vs Frequency



LMP7711 Features

Benefits

- Input offset voltage ±150 µV (max) → Improves system accuracy
- Input bias current 100 fA → Allows easy interfacing from any resistive source
- Input voltage noise 5.8 nV/√Hz → Accurate low frequency signal conditioning
- Gain bandwidth product 17 MHz at 1.15 mA → Unity gain stable with minimum power consumption
- Operating temperature range -40°C to 125°C → Performance across automotive and industrial temp range

Op Amps

Product ID	Key Features	Typ. Supply Current (mA)	Supply Voltage Range (V)	Input Offset Voltage (mV) max	Unity Gain Bandwidth (MHz)	Low Input Current CMOS Design	Temp Range (°C)
LMP7711	Precision, Low-Noise RR/O CMOS	1.15	1.8 to 5.5	0.15	17	✔	-40 to +125
LMP7701	Precision, 12V RRI/O CMOS	0.73	2.7 to 12	0.2	2.5	✔	-40 to +125
LMV651	90% Power Saving RR/O Performance Amp	0.11	2.7 to 5.5	1.0	12	—	-40 to +125
LMV791	Low-Noise, Low I_{BIAS} RR/O	0.95	1.8 to 5.5	1.3	14	✔	-40 to +125
LPV511	880nA, Ultra Low Power 12V RRI/O	880 nA	2.7 to 12	3.0	0.027	—	-40 to +85

Comparators

Product ID	Key Features	Typical Supply Current (nA)	Supply Voltage Range (V)	Input Offset Voltage (mV) max	Prop Delay Time (µs)	Low Input Current CMOS Design	Temp Range (°C)
LPV7215	Ultra Low-Power RRI/O	580	1.8 to 5.5	3.0	6.6	✔	-40 to +85



For FREE samples, datasheets, and Signal Path Designer℠ articles, visit:

amplifiers.national.com

Or call 1-800-272-9959

National Semiconductor

© National Semiconductor Corporation, 2005. National Semiconductor, N, LMP, LMV, and VIP are registered trademarks of National Semiconductor Corporation. All rights reserved.

is zero, as is a sine wave's. However, the average power is *not* zero. Therefore, when summing the contributions of different noise sources, you add the power of each source to get the total power. Power, P, is proportional to voltage, V, squared and inversely proportional to the resistance, R, at the node:

$P=I\cdot V=(V/R)\cdot V=V^2/R.$

With all of the noise sources referred to the same node, they will be across the same impedance. Therefore, you can calculate the total noise power at that point. If you want the related total voltage, reverse the equation; that is, enter P and either I or R and solve for V.

The noise sources in **Table 2** are uncorrelated, and you can sum them as the preceding paragraphs describe. Correlated noise results from a single source or from dependent sources that relate the behavior of one source to another. Because the noise behavior of correlated sources is related, you can't simply add the source powers.

TABLE 2 AMOUNT OF NOISE PER NOISE SOURCE

Noise source	Noise (as a voltage)	Noise gain
Input-voltage noise	Vn	$1+R_F/R_G$
Inverting-input current noise	$In-\times R_F$	1
Noninverting-input current noise	$In+\times R3$	$1+R_F/R_G$
Johnson noise of R_F	$\sqrt{(4KT\times R_F)}$	1
Johnson noise of R_G	$\sqrt{(4KT\times R_G)}$	$-R_F/R_G$ (inverting)
Johnson noise of R_{NINV}	$\sqrt{(4KT\times R_{NINV})}$	$1+R_F/R_G$

TABLE 3 TYPICAL VALUES FOR NOISE QUANTITIES IN VFA, CFA AND CMOS TOPOLOGIES

	VFA	CFA	CMOS
V_N	0.86 nV/√Hz	4 nV/√Hz	20 nV/√Hz
IN−	1.4 pA/√Hz	20 pA/√Hz	2 fA/√Hz
IN+	1.4 pA/√Hz	8 pA/√Hz	2 fA/√Hz

VFA AND CFA NOISE ANALYSIS

To understand the noise differences between VFAs and CFAs, you need only compare the architectural differences between their input stages (**figures 1** and **2**). The VFA input structure is a differential pair. Therefore, in bipolar technologies, the inputs connect to bases of PNP or NPN transistor pairs or to both. The currents through these nodes are small base currents; because the noise current is proportional to the base current, low-input-noise current results.

The CFA, on the other hand, has two inputs connecting to very different structures. The noninverting op-amp input connects to the base of bipolar transistors, so the noise current is comparable with that at the inputs of VFAs. Conversely, the inverting op-amp input is the buffer's output, typically NPN and PNP emitters. Because emitter current is much larger than base current (by a factor of the current gain, β), the noise is proportionally higher, as well. CFA inverting-input noise currents typically are in the 20- to 30-pA/√Hz range, compared with the VFA's 1- to 5-pA/√Hz typical range.

The feedback resistor, R_F, transforms this larger noise current into a voltage. Input-referred noise voltage is a more complicated parameter, being a function of not only the input transistors (primarily transistor base resistance and collector current), but also the type of load the input stage drives. It is generally sufficient to say that CFAs typically deliver an input-noise voltage that is at least as low as that of VFAs that haven't been optimized for low noise. **Table 3** shows typical noise currents and voltages for a VFA, a CFA, and, for comparison, a CMOS amplifier.

VFA circuits are optimized for sensitivity to the input-voltage difference. Therefore, the voltage-noise contribution is the lowest of the three. The current noise at both inputs is low because the base current into each terminal is small. For the CFA, the feedback node has emitter current flowing instead of a base current. This larger current naturally has a larger current noise associated with it.

In the CMOS case, the input is purely capacitive (**Figure 5**). The input is again a differential pair. Because both inputs connect to MOSFET gates, which allow virtually zero current flow, only the voltage determines the output signal, explaining the

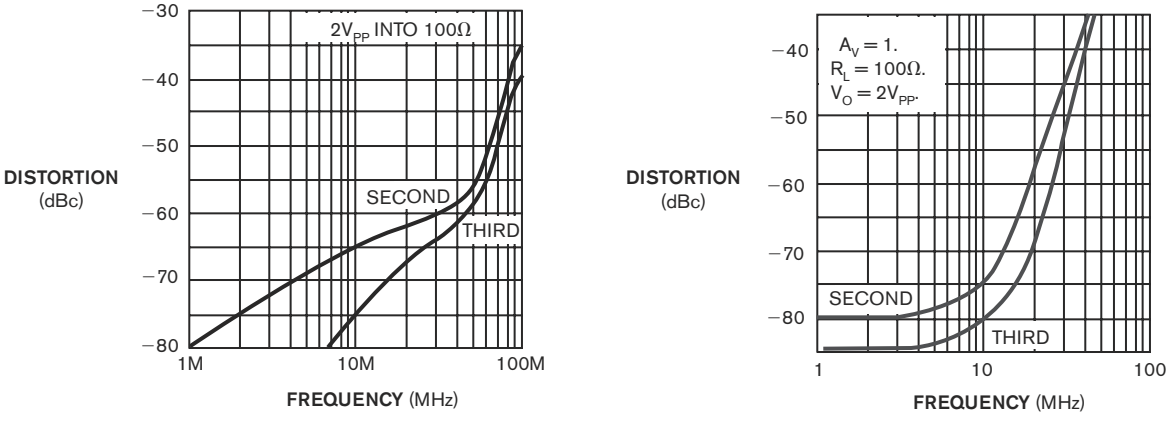
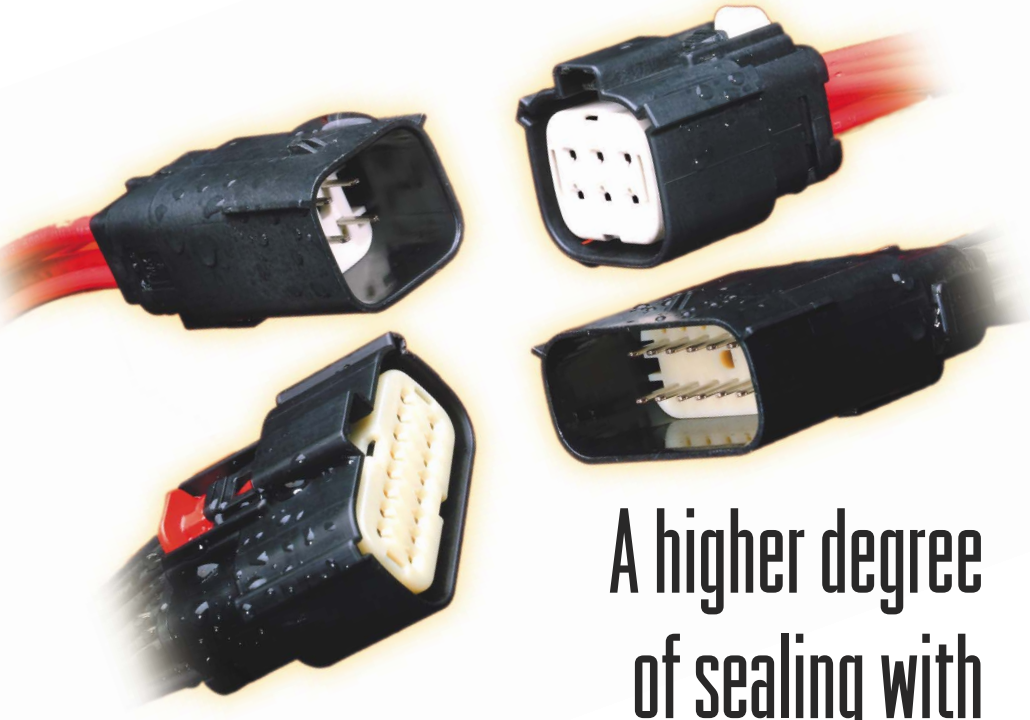


Figure 6 These data-sheet curves show typical second- and third-harmonic-distortion values for CFAs (a) and VFAs (b).

The MX150™ family represents the highs and lows of interconnection:





The pre-assembled MX150/150L connector system offers rugged sealability and affordability.

That's right, the pre-assembled MX150 product line includes seals, housings and terminal position assurance (TPA) in one connector. This means you simply crimp, poke and plug your way to a fully protected, environmentally-sealed connector.

Suitable for a wide wire range of signal and power applications, the MX150 family was designed specifically to take on harsh and wet conditions – such as those found in RVs, off-road construction vehicles, agricultural equipment, industrial machinery, outdoor lighting, boats, and other tough industrial and commercial environments. This product meets IEC IP67 requirements, complies with UL/USCAR-2 standards and offers UL and SAE wire compatibility.

In addition, Molex is your single source for just about every kind of innovative industrial connector technology. And, if need be, we can work with you to design a custom solution that meets your precise specifications.

When it comes to high performance interconnects and integrated subsystems for harsh environments, we've got your solution all sealed up.

A higher degree of sealing with lower applied costs

Industrial Division Headquarters
Pinellas Park, FL U.S.A.
Tel: 800-800-0449

Far East North Headquarters
Yamato, Japan
Tel: 81-462-65-2324
feninfo@molex.com

Far East South Headquarters
Jurong, Singapore
Tel: 65-6-268-6868
fesinfo@molex.com

European Headquarters
Munich, Germany
Tel: 49-89-413092-0
eurinfo@molex.com

Corporate Headquarters
2222 Wellington Court
Lisle, Illinois 60532 U.S.A.
Tel: 630-969-4550
Fax: 630-969-1352

molex®

Bringing People & Technology Together, Worldwide℠

www.molex.com/ind/mx150.html

© 2004, Molex

CMOS amplifier's low level of input-current noise. The input-voltage noise, though higher in the CMOS case, is still within an order of magnitude of the other two examples. So, if the voltage gain is low, as in transimpedance amplifiers, the higher noise is inconsequential. A drawback of CMOS amplifiers is that the 1/f-knee frequency is inversely proportional to the device channel lengths, so the more advanced the process, the higher the frequency of the 1/f knee.

TABLE 4 SUMMARY OF OP-AMP TOPOLOGIES, STRENGTHS, AND APPLICATIONS

Topology	Strengths	Example use
VFA	Input symmetry	Communications systems
	Low input voltage and current noise	
	Low distortion at low frequency	
CFA	Slew rate	ADC driver
	Bandwidth	
	Low distortion at high frequency	
CMOS	Dynamic range	Transimpedance amplifier/photodetector
	Rail-to-rail operation	
	Lowest input current noise	

VFA AND CFA DISTORTION CHARACTERISTICS

At low frequencies, VFAs provide the lowest distortion. The differential-pair input stage acts much like an electronic seesaw. When the op amp encounters a negative feedback, it attempts to level the seesaw. **Figure 6** provides distortion values from the data sheets of a typical CFA and VFA. Of course, there are products on the market that do not follow these curves. Check the data sheet before choosing an amplifier for your application.

The CFA accepts a voltage at its noninverting input and a current at its inverting input. The seesaw effect is still there, but only after $V_{IN}+$ translates into a current. This translation is imperfect, introducing errors that appear in the second-harmonic distortion. At higher frequencies, most of the loss comes from slew-rate limitations. Because CFAs have higher slew rates than VFAs, they exhibit lower distortion characteristics at high frequencies. CFAs also maintain relatively constant distortion at different gain settings.

MORE AT EDN.COM

We encourage your comments! Go to www.edn.com/ms4145 and click on Feedback Loop to post a comment on this article.

In xDSL systems, communications signals travel through telephone lines whose lengths can reach 20,000 feet. The receive signal can be as small as 30 mV with a 4-MHz bandwidth. Amplifying this signal requires a low-noise amplifier. Filtering is also necessary to remove high-frequency noise from the lower frequency transmit signal.

The line receiver's closed-loop gain must be at least 30V/V, and the driver front end's ADC has 14-bit resolution. To use the full range of the 14-bit ADC, the input SNR (signal-to-noise ratio) must exceed 84.3 dB. For example, a 20-mV input signal would require a noise level of less than 1.2 µV. The limit of the amplifier's input-voltage noise is 0.9 nV/$\sqrt{\text{Hz}}$ with a 4-MHz bandwidth. You should use a VFA—not only for its low input-voltage noise, but also because VFAs are more flexible in active-filter configurations.

DRIVING AN ADC

CFAs excel at driving high-speed, high-resolution ADCs, especially for pulsed inputs. A distinct CFA advantage for this application is that the CFA's output rise time remains nearly constant, regardless of the output step size. The slewing current is equivalent to the inverting-input current during transients, which is a function of the voltage difference across R_F. Therefore, the CFA's slew rate actually increases as the step size increases. Whereas a VFA may become slew-rate-limited for voltage swings of less than 1V, CFAs typically do not reach slew-rate limit for steps smaller than several volts.

In addition to its slew-rate advantage, the CFA offers exceptional bandwidth (be careful; excess bandwidth still contributes to total noise), distortion, settling time, and relatively low supply current, which make it a prime contender for ADC drivers. For example, the EL5166 is a good choice for driving 14-bit ADCs, because of its 1.4-GHz bandwidth, 6000V/µsec slew rate, and 70-dB second harmonic distortion at 20 MHz. With ADC drivers, the load that the CFA's feedback network presents is not usually a concern. This characteristic allows designers to use low-value feedback resistors to minimize noise and maximize the driver's performance.

TRANSIMPEDANCE AMPLIFIER

Wide bandwidth and low input-bias and noise currents make modern high-speed CMOS amplifiers ideal choices for photodiode transimpedance amplifiers. The key elements in a transimpedance design are capacitances at the inverting input (including diode, amplifier-input, and parasitic capacitance), the transimpedance gain set by R_F, low input-current noise to allow wide dynamic range, and sufficient gain-bandwidth product (**Figure 7**). With these four variables set, you often need a feedback capacitor in parallel with R_F to control the frequency response and ensure stability.

If the amplifier is a rail-to-rail, single-supply device, you can connect the noninverting input to ground, allowing the output to reach true zero when the photodiode is not exposed to any light. This setup allows the circuit to avoid the delay that the output would need to travel from the negative rail.

To achieve the best performance, select components according to the following guidelines:

- For lowest overall system noise, select R_F to provide all of the required transimpedance-stage gain. Because the CMOS amplifier has virtually no current noise, a lower R_F value (to lower the transimpedance-stage noise) would necessitate including additional gain stages, ultimately producing poorer overall noise performance. The noise that R_F produces increases as the square root of resistance, whereas the signal value increases lin-

Talk about a generation gap.

The new Tektronix AFG3000 Series signal generators vs. the competition.



Starting at $1,780.* Unlike the subtle advancements offered in other arbitrary/function generators of past decades, our powerful and broad line of arbitrary/function generators delivers serious advantages. The large display confirms your settings at a glance. Sine waveforms reach as high as 240 MHz. And you get a front-loading USB port, two-channel capability, and a remarkably intuitive GUI. Visit **www.tek.com/generation_gap/edn** to see the next generation of signal generation.

The Next Generation.

www.tek.com/generation_gap/edn

Tektronix®

Enabling Innovation

© 2005 Tektronix, Inc. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. TEKTRONIX and the Tektronix logo are registered trademarks of Tektronix, Inc. *Tektronix MSRP subject to change without notice.

early. Therefore, placing all of the required gain in the transimpedance stage improves the SNR.

- Minimize capacitance at the inverting input. This capacitance causes amplification of the op amp's voltage noise. A low-noise voltage source to reverse-bias a photodiode can significantly reduce its capacitance. Smaller photodiodes have lower capacitance. Use optics to concentrate light on a small photodiode.
- Because noise increases with increased bandwidth, limit the circuit bandwidth to only what is necessary. To limit bandwidth, parallel the feedback resistor with a capacitor, even if stability is not an issue.
- PC-board leakage can degrade the performance of an otherwise well-designed amplifier. Carefully clean the pc board. A pc-board guard trace that encircles the summing junction (inverting input) and drives at the same voltage as the summing junction can help control leakage.

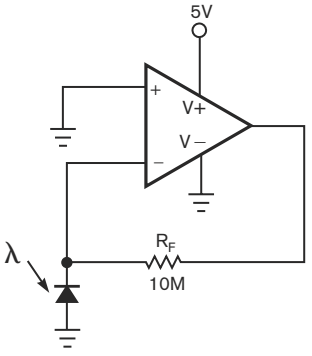


Figure 7 Among the key elements in a high-speed transimpedance amplifier for use with a photodiode are capacitances at the inverting input (including diode, amplifier-input, and parasitic capacitance).

Both CFA and VFA topologies are popular choices for high-speed applications. An understanding of the differences in circuit topology, along with basic noise and distortion characteristics, is crucial for optimal product selection. **Table 4** summarizes the aforementioned discussion and examples. EDN

AUTHORS' BIOGRAPHIES

Jeffrey Lies is a principal application engineer for analog-signal-processing circuits at Intersil Corp. He graduated from the University of California—Berkeley with a BSEE in 1979.

Tamara Papalias is a principal application engineer for analog applications at Intersil. She is also a full-time professor at San Jose State University (CA). She has a BSEE, MSEE, and PhD in RFIC design from Stanford University (Stanford, CA).

Mike Wong is the director of application engineering at Intersil, focusing on high-speed analog applications. He previously worked on power supplies at Astec. He graduated from University of California—Davis with a BSEE in 1989.

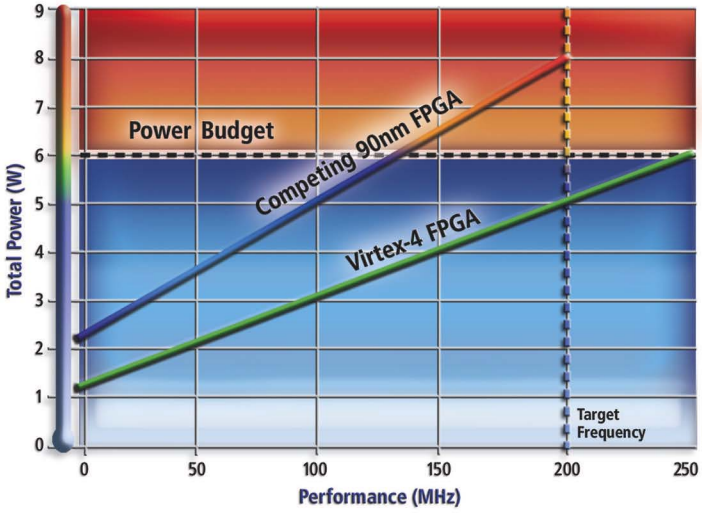




With Competing FPGAs, Power Has Become a Burning Issue.

LX SX FX

Design Example:



Design Example: LX60 vs. 2S60. Target Frequency = 200 MHz. Worst-case process.
20K LUTs, 20K Flip-Flops, 1Mbit On-Chip RAM, 64 DSP Blocks, 128 2.5V I/Os
Based on Xilinx tool v4.1 and competitor tool v2.1
For higher density devices, achieve up to 5W lower power

VIRTEX V4

Get 1-5W lower power per FPGA, only with the Virtex-4 family

Check the specs for yourself at realistic operating temperatures (T_j = 85°C). Different logic architecture or dielectric just won't do it. No competing FPGA comes close to Virtex-4 for total power savings–take it to the lab and see.

- **73% lower static power**
- **Up to 86% lower dynamic power**

Unique Triple-Oxide Technology & Embedded IP

At the 90nm technology node, power is the next big challenge for system level designers. An inferior device can suffer leakage, dramatic surges in static power, and thermal runaway. That's why we designed our Virtex-4 FPGAs with Triple-Oxide Technology™, embedded IP, and power-saving configuration circuitry. Now you can meet your performance goals, while staying within the power budget.

Visit ***www.xilinx.com/virtex4/lowpower*** today, and get the right solution on board before your power issues start heating up.

FPGA and Structured ASIC JOURNAL READER'S CHOICE AWARDS

Highest customer satisfaction:
- Virtex & Spartan FPGAs
- ISE design tools
- Support

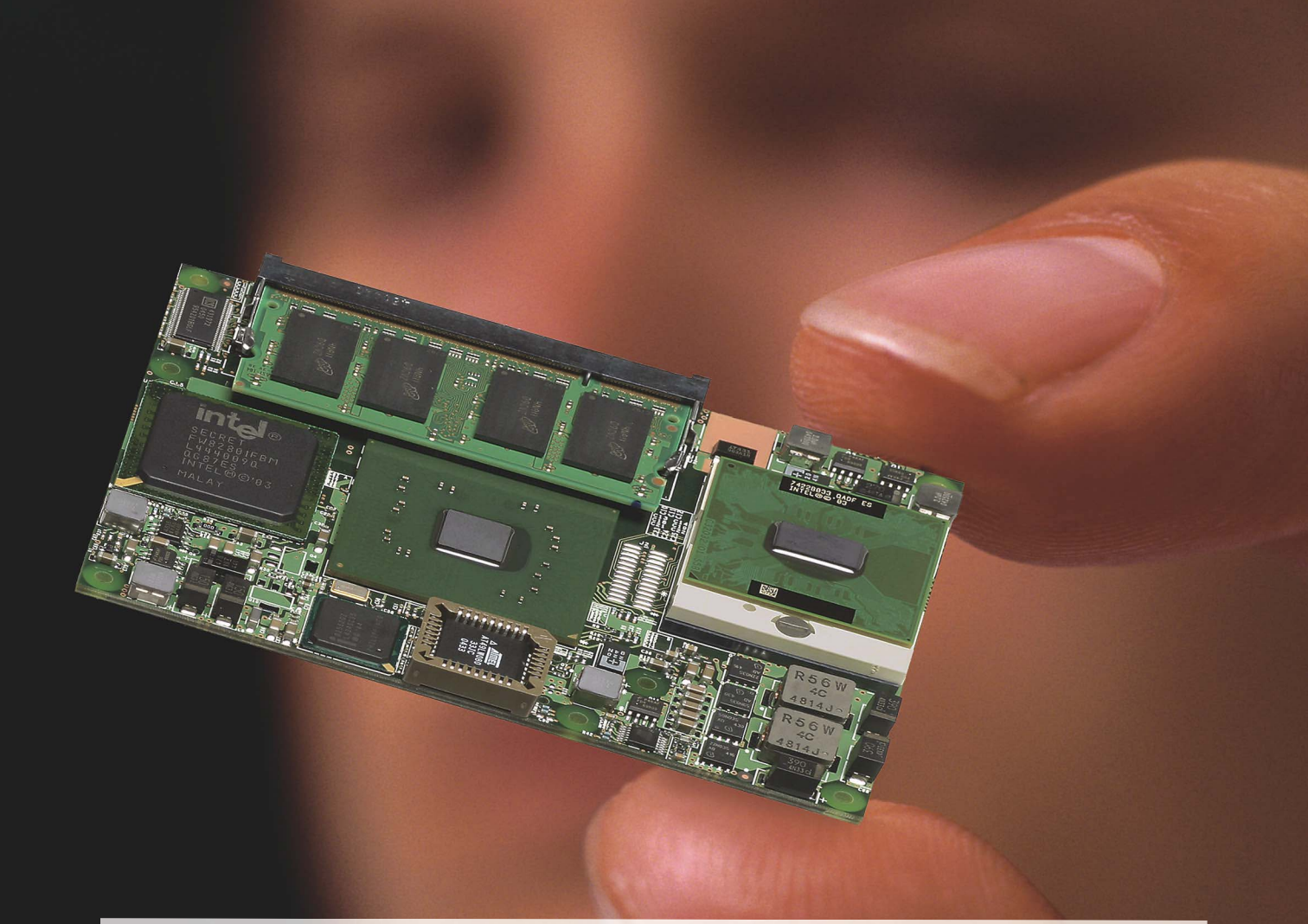
XILINX®
The Programmable Logic Company℠

www.xilinx.com/virtex4/lowpower

www.techonline.com
View The TechOnLine Seminar Today

Breakthrough Performance At The Lowest Cost

©2006 Xilinx, Inc. All rights reserved. XILINX, the Xilinx logo, and other designated brands included herein are trademarks of Xilinx, Inc. All other trademarks are the property of their respective owners.



BY WARREN WEBB • TECHNICAL EDITOR

Serial streams shrink embedded-system designs

MOBILE- AND SMALL-FORM-FACTOR-PRODUCT DESIGNERS TURN TO FABRIC TECHNOLOGY AND OFF-THE-SHELF COMPUTER MODULES TO BEAT THE COMPETITION.

A new wave of extremely compact embedded computing platforms is finding its way into industrial, medical, consumer, and other space-critical applications. Despite their compact size, these small, off-the-shelf computing elements offer designers full processing performance and complete I/O features in both proprietary and standards-based form factors. These undersized but capable computer modules let designers skip the most complex portion of embedded-product design and concentrate on the custom circuitry unique to their design and reduce hardware- and software-development schedules.

As systems shrink and clock speeds escalate, product designers face the daunting task of developing a high-performance, state-of-the-art processor section to drive their custom embedded circuitry and still meet footprint constraints. To bypass this complex design and beat the competition to market, many designers are turning to new, small-form-factor, plug-in modules that integrate the CPU and standard peripherals. These off-the-shelf processor modules allow designers to trade substantial savings in NRE (nonrecurring-engineering) charges for slightly higher recurring costs.

Plug-in processors, also known as COM (computer-on-module) processors or core modules, make sense in embedded-system designs in which a single pc board houses all electronics, including the CPU, processor peripheral interfaces, mass storage, and application-specific circuitry. Single-board electronics typically find use in smaller or portable embedded systems, such as instrumentation, medical products, set-top boxes, kiosks, and game consoles. With a compatible baseboard design, you can purchase a large portion of the system's computer and general-purpose electronics on a replaceable plug-in module to shorten design schedules, ease system debugging, simplify upgrades, and reduce life-cycle costs.

A replaceable processor section provides several technical and economic advantages over traditional single-board designs. For example, designers can provide their embedded systems with a more sophisticated processor section to take advantage of advanced features, such as networking, graphical displays, complex software, and real-time operating systems, that would be difficult to implement on a restricted design budget. Instead of designing with an 8-bit processor with limited peripherals, processor and peripheral modules allow designers to easily step up to a 16- or 32-bit processor with a choice of state-of-the-art I/O.

Specifying an off-the-shelf processor section also affects the makeup of the embedded-system-design team. Depending on the complexity of the processor section, you may be able to reduce the number of designers a project requires. The software-design team becomes a major beneficiary because a working CPU section becomes available long before the hardware debugging of application-specific devices. Because most embedded-hardware-debugging problems occur in the more complicated CPU section, a module computer also bypasses many of the headaches of system checkout.

MEZZANINE MOVEMENT

The plug-in-processor concept is not new; however, small-form-factor designers have struggled to get the needed functions from existing modules. Along with numerous proprietary modules, the current PPMC (Processor PCI Mezzanine Card) and PC/104 standards provide off-the-shelf computing hardware to support plug-in-processor designs. PPMC is an extension of the original PMC (PCI Mezzanine Card) concept of providing replaceable I/O modules in embedded systems. VITA (VMEBus International Trade Association) maintains the PPMC specification, VITA32. With a connector arrangement meant for stacking boards without a card cage or backplane, a PC/104 computer board can also serve as a mezzanine processor on an embedded baseboard. These modules have the additional advantage of letting designers stack another I/O module on top of the processor if they run out of board space.

To increase bandwidth, reduce the number of connector pins, and reduce overall board area, module computer manufacturers are turning to switched-fabric technologies, such as Ethernet, PCI Express, Rapid I/O, and InfiniBand. Switched-fabric architectures eliminate many of the problems associated with parallel, multidrop bus schemes. Datapaths may change dynamically to support multiple simultaneous data transfers. Each connection is also a direct point-to-point

AT A GLANCE

- Fabric-based module computers package the CPU, mass storage, and peripheral interfaces on a replaceable mezzanine card.
- Small-form-factor computing modules allow designers to update and retrofit embedded devices without product redesign.
- A new COM Express standard compresses a high-performance processor and PCI Express interface into a 125×95-mm form factor.
- MicroTCA packages Advanced-MC (Advanced Mezzanine Card) modules directly into a backplane for smaller, lower cost applications.

datapath, yielding better electrical characteristics and higher bandwidth than bus architectures. A sophisticated switched-fabric system can also increase system availability by routing around defective paths or nodes.

Because of its compatibility with driver and operating-system software, several module standards include PCI Express. The developers of PCI Express based it on LVDS (low-voltage differential signaling) for maximum bandwidth between nodes. The basic PCI Express link comprises two signal paths that use small differential-voltage swings and constant-current line drivers to communicate at 2.5 Gbps in each direction. Designers expect this data rate to increase to 10 Gbps in each direction as silicon production technology improves. Low-voltage swings deliver low noise signals at low power consumption. You can easily increase the bandwidth of an individual PCI Express link by simply adding signal pairs, or "lanes," until you reach the desired performance level. The PCI Express specification supports one-, two-, four-, eight-, 16-, and 32-lane widths.

PFU, Kontron, Intel, and RadiSys originally sponsored COM Express, an open PICMG (PCI Industrial Computer Manufacturers Group) industry standard for COMs for small-form-factor designs. The standard implements new technologies in such a way that designers can maintain compatibility with legacy circuitry or create new legacy-free products. COM Express includes PCI Express to replace the PCI bus, PCI Express Graphics to replace AGP (Accelerated Graphics Port), and Serial ATA (Advanced Technology Attachment) to replace Parallel ATA. The processor-architecture-agnostic COM Express defines only industry-standard system-I/O interfaces.

For COM Express, PICMG defined a compact basic form factor measuring 125×95 mm and an extended form factor measuring 155×110 mm. With the same connector and pin definitions, the two sizes are interchangeable, and the extended form factor allows for double the memory capacity and dual-channel memory configurations. COM Express board-to-board connectors comprise two rows of 220 pins each. The required first row includes pins for PCI Express, Serial ATA, display, system and power management, networking, and power and ground interfaces. The optional second row provides digital video and legacy PCI and IDE signals plus additional PCI Express, networking, and power and ground signals.

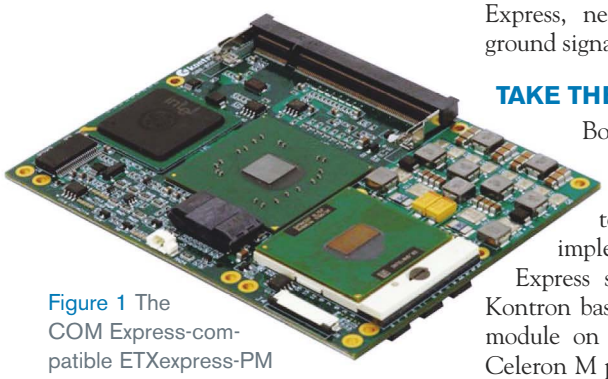


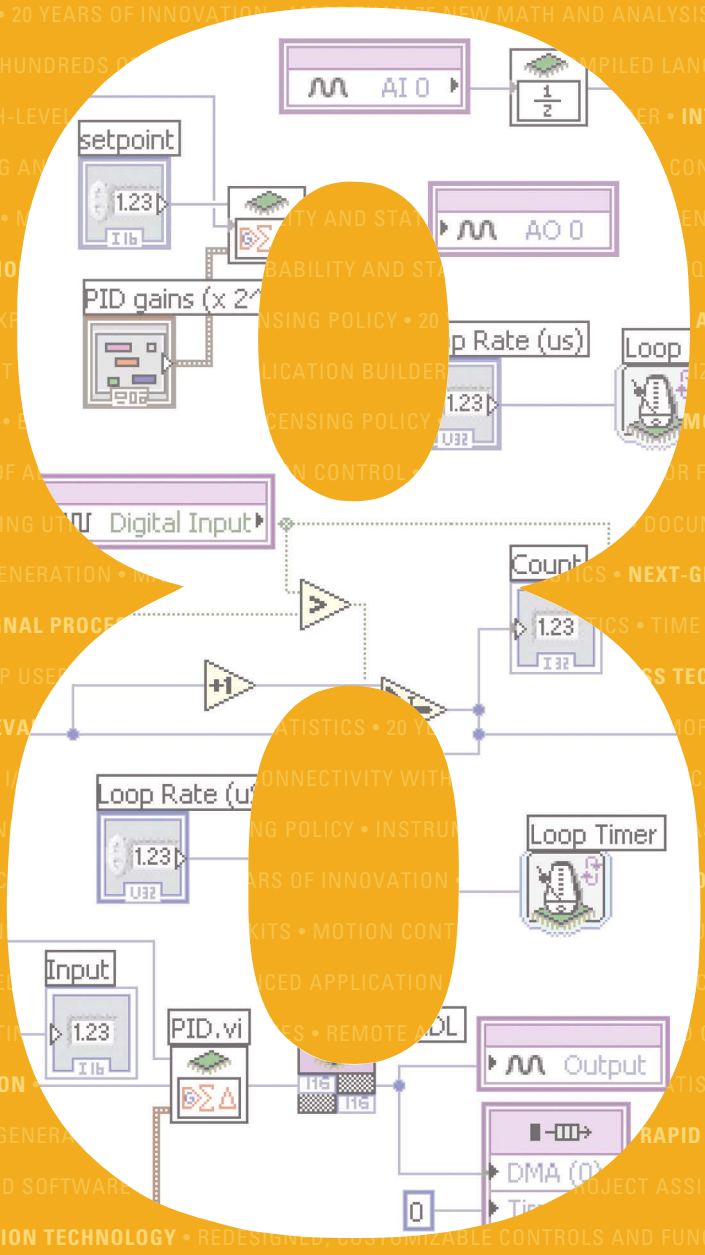
Figure 1 The COM Express-compatible ETXexpress-PM module from Kontron provides a low-power processor along with state-of-the-art-I/O interfaces.

TAKE THE EXPRESS

Board manufacturers have adapted the ETX (Embedded Technology Extended) Express form factor to implement the PICMG COM Express specification. For example, Kontron based its new ETXexpress-PM module on the Intel Pentium M and Celeron M processors, as well as on the Intel 915GM chip set; the module conforms to COM Express (**Figure 1**). PCI Express is the primary datapath, and a 32-bit PCI 2.1 interface supports legacy PCI-bus applications. The ETXexpress-PM will support four PCI Express lanes and PCI Express cards, as well as established hardware, such as the 32-bit PCI bus. For applications that require real-time video capabilities, the ETXexpress-PM has both Intel Extreme Graphics 2 and PCI Express graphics. The board also has 10/100BaseT Ethernet-port networking and USB 2.0 for external peripherals. ETXexpress COM modules will also provide optional interfaces for Serial ATA, Parallel ATA, LVDS multimedia ports, and ACPI (Advanced Configuration and Power Interface) for power management.

PFU Systems also offers a family of COM Express-compliant modules targeting healthcare, gaming, entertainment, test, industrial-automation, and security applications. The company's Plug-N-Run G4 modules are available with Intel Pentium M and Celeron M processors, featuring as much as 2 Mbytes of L2 cache, a 533-MHz front-side bus, a 533-MHz DDR2 memory controller, and an integrated Intel graphics-media accelerator (**Figure 2**). The devices allow for flexible man-machine interfaces with built-in USB 2.0, AC 97/HD audio, realistic 3-D-graphics rendering, MPEG-2 decoding, and dual independent-display, high-resolution interfaces. An integrated 10/100BaseTX Ethernet with built-in PXE (preboot execution environment) allows network boot for diskless operation and lower hardware costs. Designers can implement security features for authentication at the user, application, operating system, and BIOS levels. Plug-N-Run G4B modules in the COM Express basic form factor allow as much as 1 Gbyte of DDR2 memory expansion, and modules in the COM Express extended form factor are available with dual-channel memory configurations for as much as 2 Gbytes of memory.

Radisys has introduced the Procelerant CE COM Express-compliant product family, comprising a carrier board and four COMs for use in ultrasmall-form-factor computing systems. The modules feature a variety of Intel processors and as much as 1 Gbyte of DDR2 DRAM, dual display interfaces, an AC97 audio interface, Gigabit Ethernet, PCI Express, and PCI support. The Procelerant CR100 Flex ATX carrier development-platform board enables customers to immediately begin designing with COM Express mod-



LabVIEW 8 – Discover Distributed Intelligence

National Instruments LabVIEW 8 delivers distributed intelligence – a powerful suite of new capabilities for you to easily design, distribute, and synchronize intelligent devices and systems. Whether you are testing electronics, mechanical structures, or dynamic systems, NI LabVIEW 8 equips you to tackle the most difficult test challenges with the ease and productivity of graphical development. With more than 100 new features combined with the open, project-based LabVIEW environment, connectivity to thousands of measurement devices, and scalable development tools for projects ranging from benchtop measurements to ATE systems, LabVIEW 8 is the intelligent solution for your application.

ni.com/labview **(800) 453 6202**

© 2005 National Instruments Corporation. All rights reserved. LabVIEW, National Instruments, NI, and ni.com are registered trademarks of National Instruments. Other product and company names listed are trademarks or trade names of their respective companies. 2005-5879-821-101

NATIONAL INSTRUMENTS™

ules and use the development platform as a baseline for customer-specific COM Express carrier boards (**Figure 3**). The CR100 carrier boards bring key features from the COM Express module to connectors on the board. The expansion options on the CR100 include two 32-bit, 33-MHz 3.3V PCI slots; one PCI Express card slot; and two one-lane-wide PCI Express slots. These expansion offerings enable customers to move their I/O from PCI to PCI Express using the same module and carrier. The CR100 boards also include an LVDS flat-panel interface; dual DVI-I ports with analog VGA, USB, Serial ATA, and ATA; IEE1394; 100-Mbit Ethernet; and an ATX power connector. Prices for the Procelerant CE products start at $489 (small quantities).

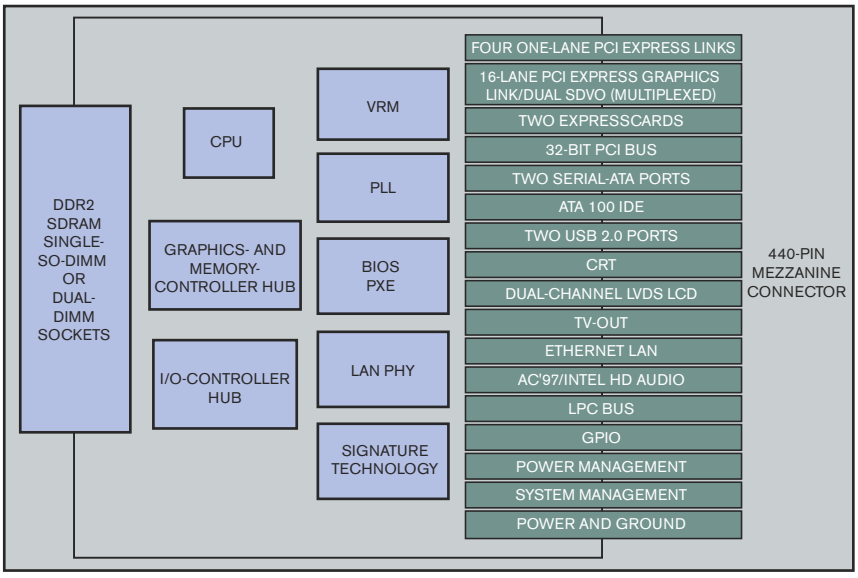


Figure 2 PFU Systems' Plug-N-Run G4 modules provide flexible man-machine interfaces in basic and extended COM Express form factors.

TELECOM TREATS

Another fabric-based-module computer standard emerged from the recent AdvancedTCA (Telecom Computing Architecture) initiative. Telecom designers wanted a hot-swappable, field-replaceable mezzanine module to lower maintenance costs and reduce downtime. To complement the high-performance features of AdvancedTCA, these new mezzanine modules also required remote management, switched-fabric technology, and a greatly improved power budget. In early 2005, PICMG released the first AdvancedMC (Advanced Mezzanine Card) specifications that define the form factor, connector, power and thermal characteristics, management, clocking, and fabric options. AdvancedMC modules include single-width, double-width, half-height, and full-height form factors. The basic single-width module measures approximately 74×183 mm. On the interconnect side, AdvancedMC supports high-speed serial interconnects, which will eventually include all of the switched fabrics that AdvancedTCA allows. The base specification defines a fabric interface with as many as 21 ports or 42 differential pairs, providing full-duplex, point-to-point connectivity between modules or to the baseboard. At 12.5 Gbps per port, AdvancedMC can handle multiple lanes of protocols, such as Ethernet, PCI Express, Rapid I/O, and InfiniBand.

You can use the single-width, full-height KosaiPM AdvancedMC from Artesyn Technologies with an AdvancedTCA or proprietary carrier cards (**Figure 4**). According to Michael Franco, hardware-engineering manager at Artesyn, "AdvancedMC is the first mezzanine architecture to provide hot swappability and integrated system management, which enables designers to remotely monitor, control, and replace individual modules in the field." Targeting use in embedded control, KosaiPM features a 1.6-GHz Pentium M processor with a 400-MHz, 3.2-Gbyte/sec front-side bus; 1 Mbyte of Level 2 cache; and SIMD (single-instruction-multiple-data) extensions for computationally intensive applications, such as multimedia and packet processing. KosaiPM also features a server-class E7501 north bridge, which gives the Pentium processor high-speed access to as much as 2 Gbytes of local ECC SDRAM. The north bridge also connects to a 64-bit PCI-X bridge, which provides high-speed access to two Gigabit Ethernet channels, as much as 128 Mbytes of flash memory, a USB interface, an I^2C system-management interface, and a front-panel 10/100BaseT management interface. KosaiPM communicates with the carrier card through two Gigabit Ethernet channels and the I^2C-based IPMI (intelligent platform-management interface). Operating-system support for KosaiPM includes carrier-grade Linux.

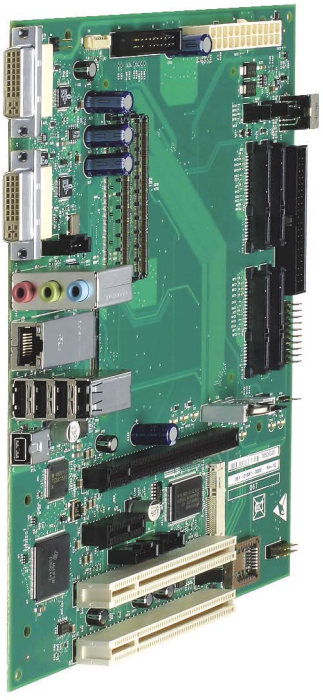


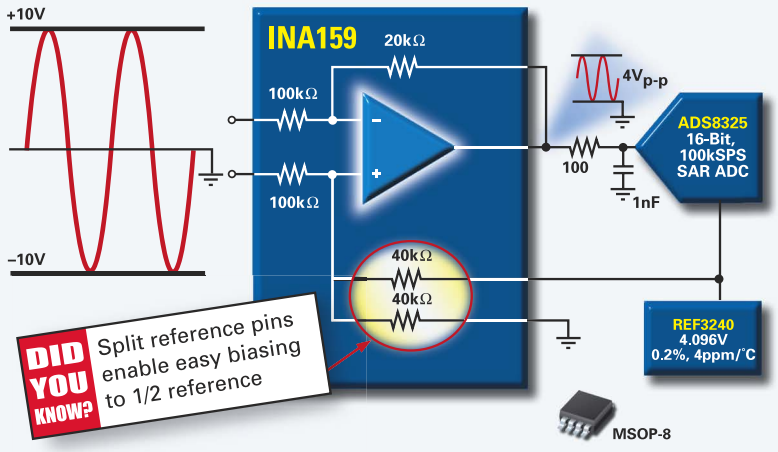
Figure 3 The Procelerant CR100 Flex ATX carrier board from Radisys serves as a COM Express development platform or carrier-board baseline.

MORE AT EDN.COM

For more information, check out the following related articles:

- "Pump it up: PCI Express," www.edn.com/article/CA316047
- "Fabric technologies reach the mezzanine level," www.edn.com/article/CA605525
- "Profit with plug-in processors," www.edn.com/article/CA238439

Connect ±10V Signals to Single-Supply ADCs



Burr-Brown Products from Texas Instruments

▶ Applications

- Differential to single-ended conversion
- Industrial process control
- Data acquisition
- Test equipment
- Instrumentation

▶ Features

- Gain of 0.2 ±0.02% (max)
- Low offset: ±100µV
- Low drift: 1.5µV/°C
- Wide bandwidth: 1.5MHz
- Single-supply operation down to 1.8V

Precision Level-Shifting Difference Amplifier

The new **INA159** is a unique, level-shifting difference amplifier with a gain of 0.2. Designed to simply and accurately interface ±10V signals to single-supply ADCs, INA159 is particularly well-suited to applications with 4.096V and 5V references. It also is designed to drive 16-bit ADCs such as ADS8325, offering a combination of low gain error, high DC precision, excellent AC performance, and low output impedance. **Achieve more:** order your samples today.

Device	Description	Ch.	Gain	Offset (µV) (max)	Offset Drift (µV/°C) (max)	CMRR (dB) (min)	BW (MHz) (typ)	Power Supply (V)	I_Q Per Ch. (mA) (max)	Package	Price
INA159	1.5MHz Precision Level Translation Amp	1	0.2	500	5	86	1.5	1.8 to 5.5	1.4	MSOP-8	$1.59
INA152	Excellent Output Swing	1	1	750	5	86	0.7	+2.7 to +20	0.65	MSOP-8	$1.20
INA132	µPower, High Precision	1	1	250	5	76	0.3	+2.7 to +36	0.185	DIP, SO	$1.40
INA2132	Dual INA132	2	1	250	5	76	0.3	+2.7 to +36	0.185	DIP, SO	$2.35
INA133	High Precision, Fast	1	1	450	5	80	1.5	±2.25 to ±18	1.2	SOIC-8/-14	$1.40
INA2133	Dual INA133	2	1	450	5	80	1.5	±2.25 to ±18	1.2	SOIC-8/-14	$2.35
INA143	High Precision, G = 10 or 0.1	1	10, 0.1	250	3	86	0.15	±2.25 to ±18	1.2	SOIC-8/-14	$1.40
INA2143	Dual INA143	2	10, 0.1	250	3	86	0.15	±2.25 to ±18	1.2	SOIC-8/-14	$2.25
INA157	High Speed, G = 2 or 0.5	1	2, 0.5	500	20	86	4	±4 to ±18	2.9	SOIC-8	$1.40

FREE! Simulate your INA159 circuit with TINA-TI™ a powerful, SPICE simulation program www.ti.com/tina-ti



www.ti.com/ina159 ○ 800.477.8924, ext. 12855

Technology for Innovators™

Texas Instruments

Technology for Innovators and the red/black banner are trademarks of Texas Instruments. TINA is a trademark of DesignSoft. 1228A0

© 2005 TI

KosaiPM costs $1500 (OEM quantities).

SBS Technologies recently introduced the single-width, full-height Telum ASLP10 AdvancedMC processor board with integrated low-power Intel Pentium M processor and dual Gigabit Ethernet channels (**Figure 5**). The module supports full hot-swap capabilities and targets use in wireless base stations, voice over Internet Protocol, test and measurement systems, media servers, base-station controllers, and server blades. The Telum ASLP10 includes as much as 2 Gbytes of 400-MHz DDR2 SDRAM with ECC and an eight-lane PCI Express data port through the AdvancedMC connector. The board also includes a management controller for power sequencing, hot-swap capabilities, and module management. Rubin Dhillon, general manager of SBS Technologies' communications division, says, "The Telum ASLP10 gives system integrators the high performance of the latest Intel Pentium M processor, Gigabit Ethernet bandwidth, and excellent thermal properties, helping them maximize their high-performance system designs. This module is designed to enable today's modular-system architectures." The Telum ASLP10 supports MontaVista Linux carrier-grade and SUSE (Gesellschaft für Software-und Systementwicklung MBH) Linux carrier-grade operating systems. The price for the Telum ASLP10 starts at $1750 (OEM quantities).

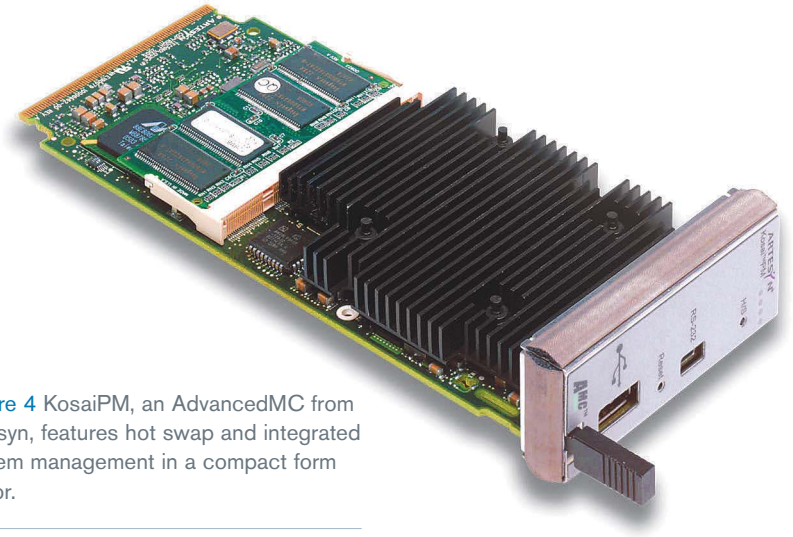


Figure 4 KosaiPM, an AdvancedMC from Artesyn, features hot swap and integrated system management in a compact form factor.

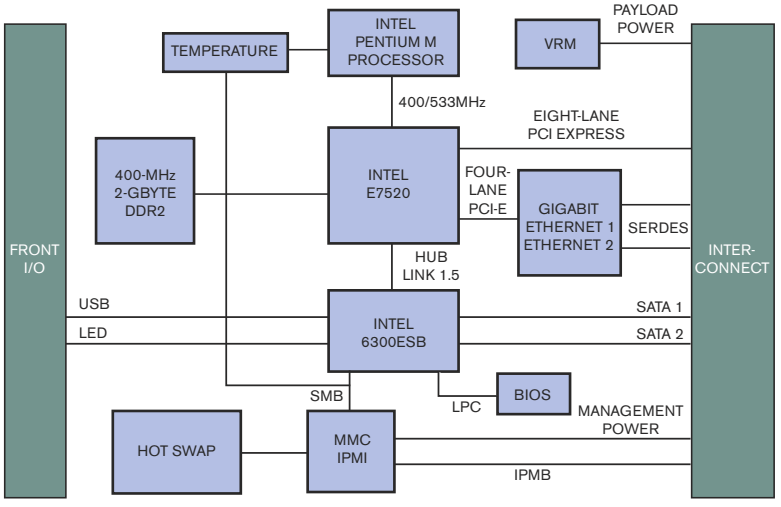


Figure 5 SBS Technologies' AdvancedMC Telum ASLP10 includes a low-power Intel Pentium M processor and dual Gigabit Ethernet channels.

MAKE MINE MICRO

With the high-performance, hot-swap, switched-fabric, and management features of AdvancedMC, designers suggest using these modules to plug directly into a backplane for small, stand-alone systems. As such, MicroTCA in October 2004 became a PICMG draft-system architecture specification. MicroTCA provides a stand-alone chassis with a backplane that directly accepts AdvancedMCs, thereby eliminating the need for an AdvancedTCA carrier board. The smaller form factor makes the concept viable for lower budget applications in telecom and a wide range of embedded-system projects. Although PICMG has not yet released it, a proposed chassis configuration includes a 4U-high×19-in.-wide unit that provides 12V payload power, management, and cooling for as many as 48 half-height, single-width AdvancedMC modules. PICMG is also considering a cube design, measuring approximately 8 in. on a side. Designers are shooting for chassis-hardware costs of approximately $500 by the projected release date of mid-2006.

New fabric-based, small-form-factor-module computers give designers the opportunity to purchase one of the most complex portions of compact- or mobile-product development. High-performance, off-the-shelf processor modules fit many embedded devices, leaving the design team with the application-specific technology, including the electronics, power supply, operator interface, packaging, and software. With a shortened design schedule and early access to a compatible software-development platform, the latest generation of plug-in processors promises to usher in a new era of rapid product development. EDN

FOR MORE INFORMATION

Artesyn Technologies
www.artesyn.com

Intel
www.intel.com

Kontron
www.kontron.com

PFU Systems
www.pfusystems.com

PICMG (PCI Industrial Computer Manufacturers Group)
www.picmg.org

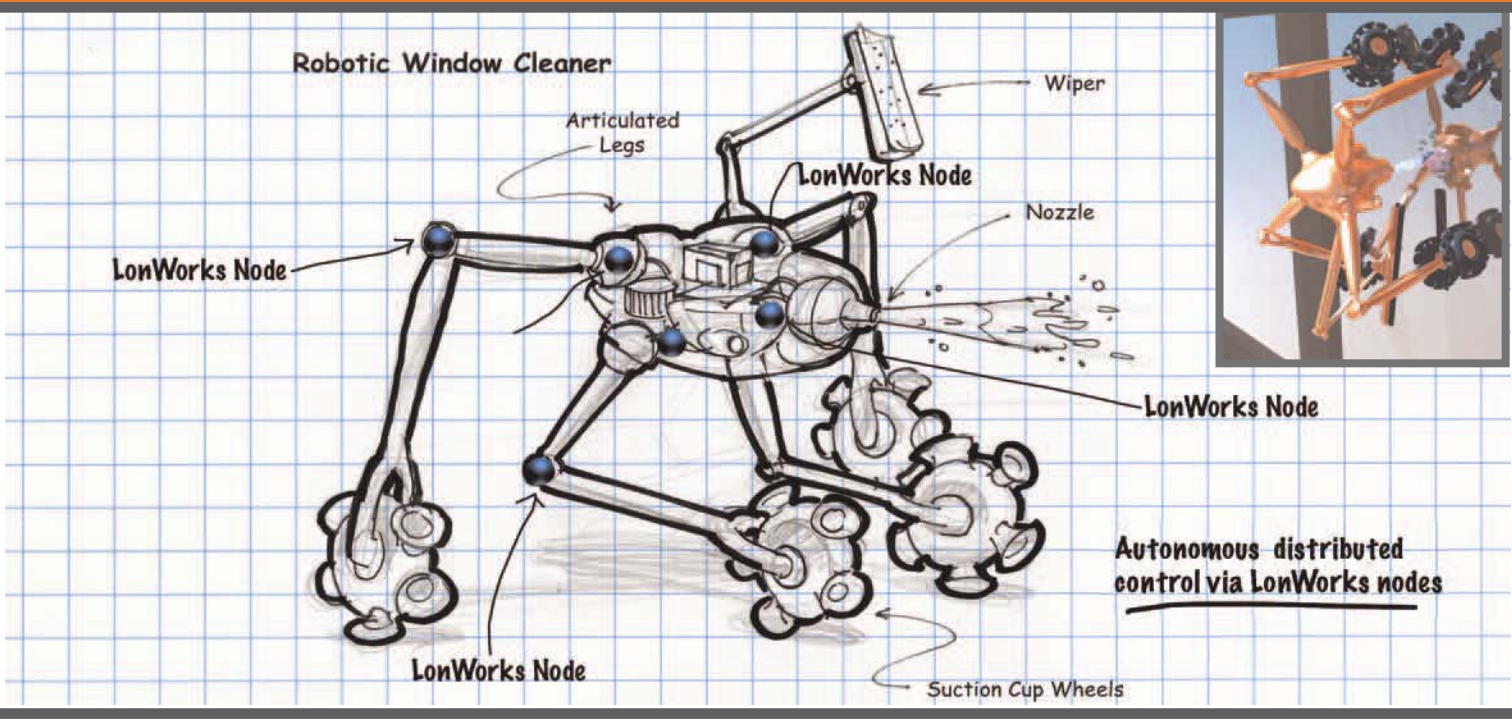
Radisys
www.radisys.com

SBS Technologies
www.sbs.com

VITA (VMEbus International Trade Association)
www.vita.com

You can reach Technical Editor Warren Webb at 1-858-513-3713 and wwebb@edn.com.





DESIGN WITHOUT LIMITS



What you design is your business. Adding distributed control throughout your application is ours. Our LonWorks® platform is a worldwide standard for networking anything you want to control—pumps, motors, valves, fans—even a remote-controlled window washer. Add networking features to your products and watch them deliver more than you thought possible. Start today with our NodeBuilder® development tool, or ease into your LonWorks development with our new Mini EVK. Call +1 408-938-5200 lto earn more about our development tools, or visit us online at www.echelon.com/embedded.

ECHELON®

©2005 Echelon. Echelon, LonWorks, and the Echelon logo are registered trademarks of Echelon Corporation registered in the United States and other countries.

Ultra Compact 2 x 20W Audio Amplifier

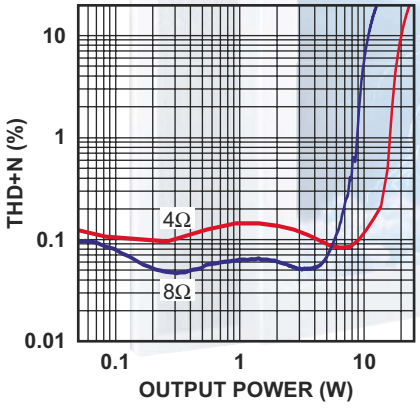


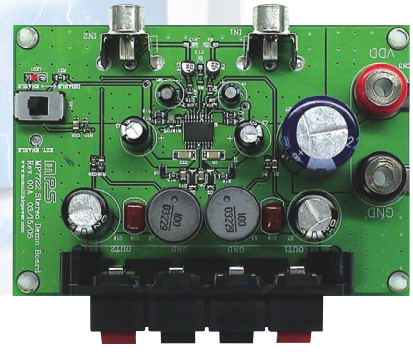
Proprietary AAM™ Class D Technology Delivers Superior Performance

- *THD+N = 0.06% @ 1W, 8Ω*
- *Integrated 180mΩ MOSFETs*
- *93% Efficiency at 20W*
- *Single Supply Operation*
- *Single Inductor Solution*
- *Class A/B Fidelity*
- *Click and Pop Suppression*
- *Mute/Standby Modes*
- *Tiny TSSOP Package*

MP7722

THD+N vs Output Power





Evaluation Board Available



Featured Audio Amplifiers

Part	V_{IN} (V)	P_{OUT} (W)	I_{OUT} (A)	Package
MP7720	9.5 - 24	20	5	SOIC8
MP7722	9.5 - 24	2 x 20	2 x 5	TSSOP20
MP7731	9.5 - 18	30	5	TSSOP20
MP7782	9.5 - 24	50	5	TSSOP20
MP8040*	7.5 - 24	70	9	SOIC8

** Integrated 1/2 Bridge*



DC to DC Converters CCFL / LED Drivers Class D Audio Amplifiers

The Future of Analog IC Technology™

www.monolithicpower.com

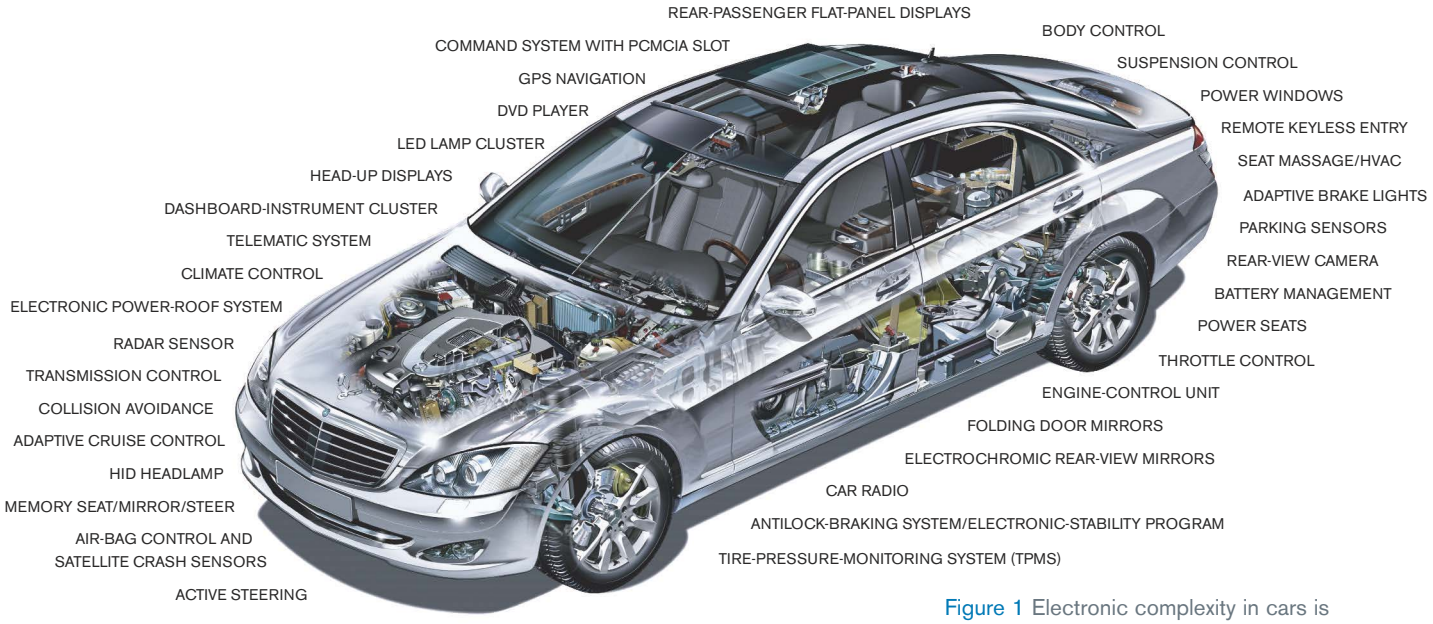


Figure 1 Electronic complexity in cars is increasing. New Mercedes S-Class cars employ at least 70 networked ECUs (electronic control units); 10 years ago, most cars had three ECUs (photo courtesy of DaimlerChrylser; source: Gartner Research, November 2005).

BY MICHAEL SANTARINI • SENIOR EDITOR

DESIGN CHALLENGES

steer automotive electronics

THE AUTOMOTIVE INDUSTRY USES SOPHISTICATED MECHANICAL DESIGN TOOLS BUT COULD BENEFIT FROM ELECTRONIC SYSTEM DESIGN AUTOMATION.

Sit in any new car, and it doesn't take long to notice that a lot more electronic components exist in vehicles today than did five years ago. But the GPS, satellite radio, DVD/video screen, automatic climate control, and gas-mileage-monitoring features, along with the AM/FM radio, CD player, and power doors, windows, and mirrors aren't all of the electronics in a vehicle.

In fact, under the hood and in the body—in just about every system in which 10 years ago an actuator drove the mechanical or hydraulic system—there is now likely an electronic sensor and switch augmenting the mechanical and hydraulic systems or even replacing them. Many of theses systems, ECUs (electronic control units), are mission-critical, controlling the brakes, air bags, and steering. As such, they have to be 100% reliable, with tolerances nearing military and aerospace requirements but at consumer-electronics prices.

About 40% of the overall cost of today's automobile involves electrical systems and software design, yet electronics is the least automated design discipline in the automotive sector.

"We used to joke that body and sheet-metal guys used an innovation called

AT A GLANCE

- Electronics and software make up 40% of an automobile's cost.
- Automotive ICs must be highly reliable and extremely inexpensive.
- Automakers design cars four years ahead of their release date.
- GM's 2004 net revenue was $193 billion. The entire semiconductor industry posted revenue of $213 billion in 2004.
- More than 25 million vehicles were recalled in 2004, more than any other year, according to the NHTSA (National Highway Traffic Safety Administration).

'CAD' to design every nonelectric piece of an automobile, and all they had left for the electronics department was an innovation called pen and paper," says Jon Friedman, who before becoming director of the automotive-industry marketing group at The Mathworks worked in electronic design at an auto manufacturer.

Now, however, driven by consumer demand for new "electronic bling" and the need to make cars more reliable, automakers are in a tizzy trying to restaff and retool an industry that until recently mechanical engineers and design software had dominated. In this new age for the automotive industry, automakers need an increasingly electronics-savvy staff and supplier-support structure that can deal with electronic-design issues that are unique to the automotive area.

In Reed Business' 2005 *Movers and Shakers* electronics forecast, the head of General Motors research-and-development group, Alan Taub, details the business challenges GM faces as the company and the rest of the automotive industry move toward the "electronification of the vehicle" (**Reference 1**). Taub describes the electronics for enriching and making safer the driving experience, such as adaptive cruise control, OnStar telematics for monitoring the automobile and the well being of its occupants, and even advanced crash-avoidance systems that steer the car away from an accident.

Industry experts see electronics as the cheaper and safer alternative to slow mechanical systems that more quickly wear out over time in automobiles. Moving to more reliable ECUs instead of hydraulics and mechanical-based systems means a safer vehicle, fewer hits on a warranty, fewer recalls, and ultimately, automakers hope, greater profit for them and the rest of the design chain.

Electronics promises to play a bigger role as automakers move to more innovation in hybridization and explore alternative fuel sources, such as hydrogen and even carbon. But employing these advanced systems and networking them present numerous challenges all the way down the automotive-electronics design chain.

THREE-TIER SYSTEM

Today's auto manufacturers, or OEMs, don't design electrical systems. Rather, they rely on "tier-one" suppliers—companies such as Bosch, Delphi, Visteon, Bose, and 70 or so others that design the electronic subsystems that make up the automobile. Tier-one vendors, in turn, rely on tier-two vendors—essentially semiconductor and pc-board-design vendors—to supply and even custom design components for each ECU.

Automakers design automobiles four years in advance of their commercial release, so auto manufacturers today are working on 2009 cars, vans, SUVs, and trucks that they will release in mid-2008.

Traditionally, auto manufacturers devise a rough electronic specification for a vehicle that contains a list of ECUs, their behavioral specifications, and some data about the networks on which the ECUs will run, including low- and high-speed CANs (controller-area networks), LINs (local-interconnect networks), and even the emerging FlexRay. "Some manufacturers will specify performance and some will even [detail] vibration characteristics, but only in rare cases will they specify the electronic components that will be used to implement those specifications," says Jack Morgan, senior director of the automotive group at Philips Semiconductors. "They do the 'paper job,' and rely on suppliers for nitty-gritty details."

After creating the rough specification, the auto manufacturers shop that specification around and take bids from tier-one suppliers. They sometimes select three or more tier-one suppliers for each ECU. The auto manufacturers typically demand that suppliers deliver a prototype—usually a breadboard—for a given ECU within six months to prove functionality.

After the prototype passes the functionality test at an OEM, the tier-one suppliers begin designing the actual scale-

TABLE 1 AUTOMOTIVE REVENUE FOR SEMICONDUCTOR COMPANIES

Ranking for 2004	Top 10 auto manufacturers	Vehicles sold (millions)	Top 10 tier-one chip buyers	Top 10 suppliers Total spending (millions)	2004 automotive-of semiconductors to automotive	IC revenue (millions)
1	General Motors	8.71	Bosch	$2100	Freescale	$1806
2	Toyota	7.83	Delphi	$1334.5	Infineon	$1363
3	Ford	6.63	Siemens	$1261.1	STMicroelectronics	$1329
4	VW Group	5.1	Denso	$1065.4	Renesas	$1107
5	DaimlerChrysler	4.31	Johnson Controls	$820	NEC	$960
6	Hyundai	3.56	Continental	$591.8	Philips	$899
7	Nissan	3.38	Mitsubishi Electric	$524.9	Bosch	$884
8	PSA Peugeot Citroen	3.36	Visteon	$513.1	Toshiba	$630
9	Honda	3.18	Clarion	$507.7	Texas Instruments	$514
10	Renault	2.55	Pioneer Electric	$459.3	Fujitsu	$482

Source: Gartner

Intersil Voltage References

Intersil High Performance Analog

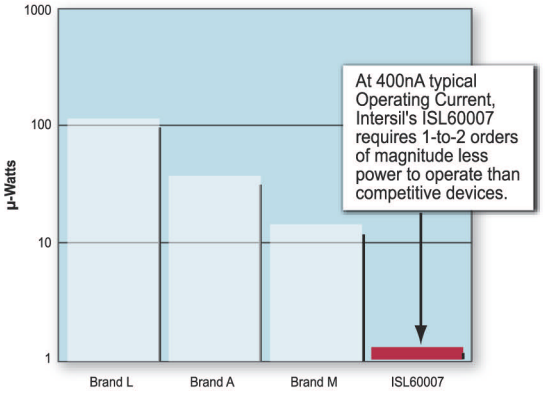
Avoid the Dreaded Choice Between Low Power and Precision



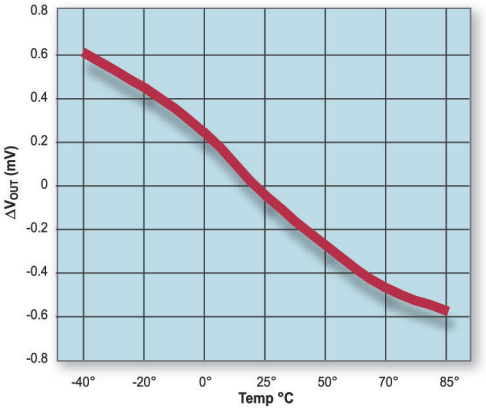
With 400nA operating current, typical power consumption of just 1.08µ-Watt and guaranteed initial accuracy as low as ±0.5mV, Intersil's ISL60007 eliminates the need to compromise accuracy and thermal stability for reduced power consumption.

Intersil's FGA™ technology enables nanopower operation, making the ISL60007 the first high-precision voltage reference with power consumption low enough to simply leave power on continuously in battery operated circuits.

RELATIVE POWER CONSUMPTION



V_{OUT} ACCURACY vs TEMPERATURE



ISL60007 Key Parameters

Description	Conditions	Device#	MIN	TYP	MAX	Units
Reference V_{OUT}	@-40°C<T_A<+85°C	ISL60007B25	-2.4995		+2.5005	
		ISL60007C25	-2.4995	2.500	+2.5005	V
		ISL60007D25	-2.4990		+2.5010	
V_{OUT} TempCo	@-40°C<T_A<+85°C	ISL60007B25			3	
		ISL60007C25			5	ppm/°C
		ISL60007D25			10	
Supply Current	@-40°C<T_A<+85°C			400	800	nA
Input Voltage	@-40°C<T_A<+85°C		2.7		5.5	V
Long Term Stability	ΔTA = 125°C		10			ppm/√1kHrs

Datasheet, free samples, and more information available at **www.intersil.com/edn**

Intersil – Amplify your performance with advanced signal processing.

©2005 Intersil Americas Inc. All rights reserved. The following are trademarks or services marks owned by Intersil Corporation or one of its subsidiaries, and may be registered in the USA and/or other countries: Intersil (and design) and i (and design).

intersil®
HIGH PERFORMANCE ANALOG

model ECUs with some help from tier-two suppliers. It is common for a tier-one vendor to supply ICs for two tier-one suppliers manufacturing the same ECU for a given auto manufacturer.

The suppliers submit the scale-model ECUs to the OEM, who designs the wire harness with essentially giant-scale routing software that helps the auto manufacturers weave the miles of wires and hundreds of points of wires that will connect the various ECUs. During this time, the specifications for ECUs can often change. The fact that some automobiles can have multiple derivatives that car dealers call "options" further complicates the process. This scenario means that vendors must supply multiple variants of a given ECU to ensure not only that it functions properly on its own but also that it does not interfere with the performance and reliability of other ECUs and in multiple system configurations.

"Traditionally, the automotive companies only start testing when the last piece of hardware becomes available; that [approach] doesn't work anymore," says Friedman. "The automotive industry has a build-then-test mentality: You bend sheet metal, forge iron, and see how [it] works. When you had one engine and one vehicle, you [could] build it and test it. But in vehicles I worked on, we had 2000 to 3000 buildable electrical combinations; you can't build all those."

Indeed, every automotive company faces the tough task of quickly balancing long automotive-design cycles and the fickle demands that consumers place on electronic gadgetry. "There is especially a lot of the pressure in the infotainment area, where consumers want a seamless experience between what they do inside their car and what they do outside their car," says David Stone, NEC's technical-marketing manager. "The industry is pushed to figure out how to bridge this history of enormous reliability and superlong planning cycles with the idea that people are changing out their consumer products every 16 months or even every year."

OEMs are trying to meet many of these demands by incorporating standard interfaces such as wired and wireless USB, Bluetooth, and others into car designs and by increasing the use of platform design or even programmable logic. All of these technologies show promise for allowing OEMs to move more easily with consumer demands and possibly update the electronics on an automobile that could be on the road for more than 10 years—the equivalent of five or six consumer-product generations.

In the last 10 to 15 years, the number of ECUs in most automobiles has climbed from three to 15, and to as many as 70 in high-end automobiles, such as the Mercedes S-class and 7-Series BMWs (**Figure 1**). Although you can attribute much of this increase to new electronic gadgetry for entertainment, once-simple functions, such as interior lighting, have become much more sophisticated.

Stephan Lehmann, strategic-marketing manager for Freescale's global automotive business, says the Volkswagen Beetle is a prime example of how the number of ECUs is increasing in a car. Lehmann notes that the old Beetle had a simple electric switch, so that when you opened a door the overhead light would come on. That light would shut off when you closed the door.

That simple switch has evolved into a complex ECU that networks into the overall body controller. That same light switch links to the doors' opening and closing and helps dim, then eventually shut off, the interior lights after a driver starts the car. It also networks to the airbag controller to turn on when the air bag deploys, so car occupants can better evaluate the situation following a collision.

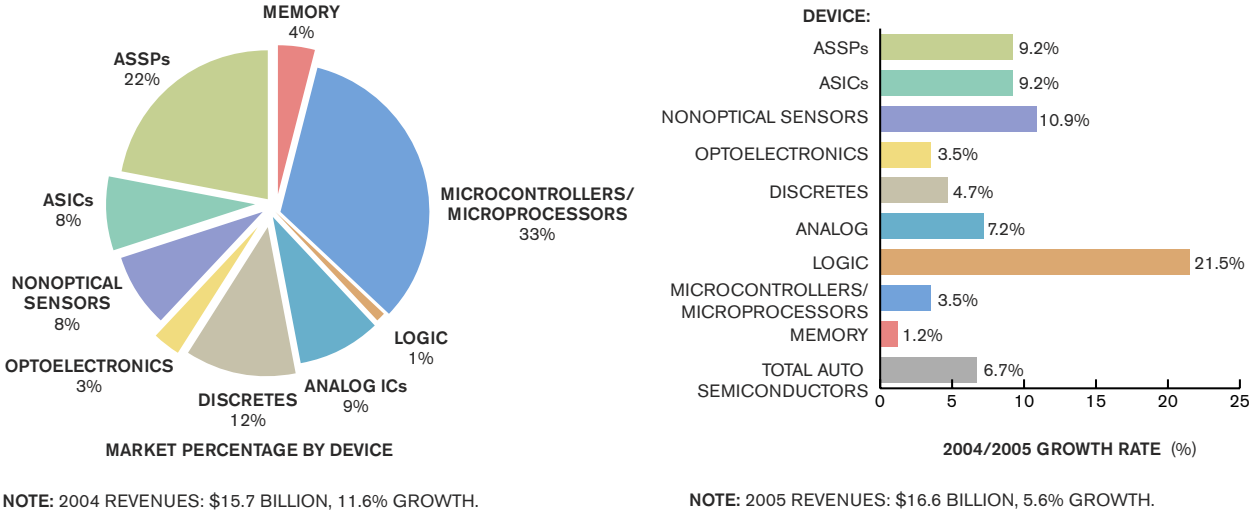
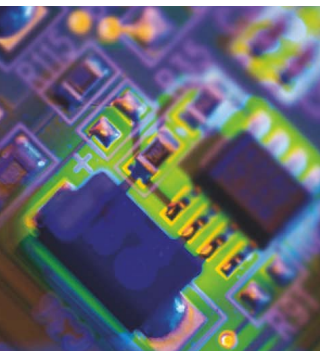
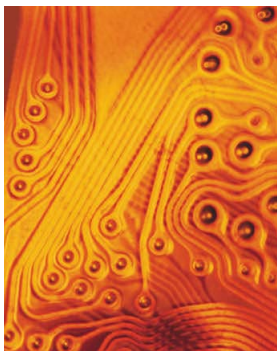


Figure 2 Semiconductor content is growing in the automotive industry. The current trend is to use more standard products (more microprocessors and controllers and ASSPs than ASICs), but ASIC use is still growing. (Charts courtesy of Gartner Dataquest November 2005 worldwide-semiconductor-forecast database.)

CIRRUS LOGIC®







Highly Integrated Stereo CODEC Ideal for Portable, Low-Power Digital Audio Applications

Free Sample

Register for a free sample of the CS42L51 today.
Plus, get the datasheet, application notes and more.

www.cirrus.com/CS42L51



- Ground-centered outputs reduce bill-of-material costs and save space—eliminating the need for large, expensive DC-blocking capacitors.
- Consumes less than 12 mW @ 1.8 V power supply.
- Available in a 32-QFN lead-free assembly.

Priced from $3.95 (US) in 1K qty.

CS42L51—New IC Minimizes Player Component Count, Size & Cost

The CS42L51 delivers excellent audio performance while providing portable device developers with an innovative solution that maximizes battery life while minimizing end-product form factors. The CS42L51's key distinction is that it operates from a single, 1.8 V power supply for low-power consumption, yet delivers plenty of output power, 46mW, into stereo 16 Ω headphones for a great listening experience. This highly integrated 24-bit, 96-kHz stereo CODEC is based on a multi-bit Delta-Sigma architecture which allows infinite sample-rate adjustment between 4 kHz and 100 kHz.

By generating its own on-chip negative power supply voltage, the CS42L51 provides ground-centered outputs, which eliminates costly, space-consuming DC blocking capacitors required by some competing solutions. The elimination of these capacitors not only reduces the implementation cost but it also greatly simplifies product design and saves valuable circuit board space.

This next-generation CODEC is an ideal choice for any portable audio product developer. For complete specifications and to register for a free sample, visit our web site today.

Applications

- Hard-disc drive & Flash-based portable audio players
- Personal media players
- Mini-disc players & recorders
- PDA's & smart phones
- Digital cameras & camcorders
- Digital voice recorders
- Wireless headsets
- Guitar effects pedals
- Portable audio recording systems
- Portable gaming systems

www.cirrus.com/CS42L51

© 2005 Cirrus Logic, Inc. All rights reserved. Free sample offer subject to availability.

Power Seminar 2006

Powerful Insights In Power

Join us for a free full-day seminar covering the latest in power optimization. Topics include:

- A fresh approach to switching regulator topologies and implementations
- Practical power application issues for switch-mode power supplies
- Understanding modern power MOSFETs
- Practical power application issues for high-power systems



Learn how to overcome even the toughest power design challenges.

Register today at

www.fairchildsemi.info/powerseminar2006

while seats last.

the power™ franchise

Global resources.
Optimized performance.
One source.

FAIRCHILD SEMICONDUCTOR®

Even analog-power devices, which heretofore transferred battery power to ECUs, have become more sophisticated. Today, power-control units have replaced traditional relay-control units.

"The power technology in lamps and windshield wipers today are really quite sophisticated," says Morgan. "It is under the control of the microcontroller, which tells it how much power to allow. Rather than just turn on, it says 'I know this load on this lamp to be 4A,' and if the load exceeds that value, the lamp will turn off immediately. A traditional relay control would just turn it on, despite the short, and would burn up. Then you would have to buy all kinds of expensive pieces instead of replacing a bulb or a small wire."

NETWORKS AND BUSES

ECUs coordinate and connect by means of an in-car network. Each automobile typically employs a minimum of three networks running simultaneously. A standard bus configuration would use high-speed CAN for power-train and safety controls, low-speed CAN for body functions, and even a subnetwork, such as LIN, for functions controlling power windows.

The most common network bus in automobiles is the CAN. By many standards, the CAN is showing its age, with critics claiming it is too slow and not deterministic enough for you to accurately set or analyze timing of signals across the network. New networks, such as FlexRay, are much faster and are more deterministic; however, there has been slow but sure adoption and support for the standard. Designers are also kicking around multiple networks for the infotainment portion of an automobile, such as MOST (Media Oriented Systems Transport) and IDB (Intelligent Transport System Data Bus).

UNIQUE DESIGN CHALLENGES

Automotive electronics is unique in that devices have to be 100% reliable across stringent running conditions but must at the same time be low cost. "The automotive environment is indeed a unique environment," says Morgan. "What is commonplace in automotive, no consumer product can survive, so all our semiconductors must work over a broad range of temperature—typically from −40 to +125°C—and typically the devices are lower power and have stringent ESD/EMI requirements. If they get a failure in a car, it is nearly a catastrophe. Everything has to work in automotive. That puts a lot of constraints on an electrical system. They are not sloppy constraints either, because as you connect all the electronic components together, you get a lot of tolerance-stack issues that don't allow you to be very sloppy."

Semiconductor and tier-one companies have to conform to OEM PPAT (production-part-approval-process) requirements and numerous standards, most notably the AECQ100 qualification flow, ISO9001, and ISO/TS 6949 (2002), which are quality guidelines for tier-two suppliers.

Vendors such as Freescale, Philips, Infineon, International Rectifier, and NEC, which also offer analog-power devices, have to be extremely careful in building and testing to these tolerances as analog devices are more susceptible to malfunction. Infineon, for example, does a lot of work on package and die reliability.

"We really look at how die and package work as a system," says Ray Notarantonio, Infineon Technologies' automotive-power-applications manager in North America. "We qualify our devices to 175°C, and that is not a trivial task. You also have to get the packages qualified to that level, too."

But although playing in the market means IC vendors must do extensive testing, they say it is well worth it, because although no electronics segment is experiencing booming growth and the automotive market and volumes aren't extremely high, automotive semiconductors provide a relatively sizable, stable revenue stream (**Table 1**). In fact, just about every IC manufacturer offers something for the automotive space.

The recent trend is for OEMs and tier-one suppliers to use more standard products and ASSPs (application-specific standard products) than ASICs. "Our suppliers have traditionally used mostly custom ASICs, and to some degree, custom processors. This [situation] is changing," says Fred Huntzicker, engineering group manager at GM. "We are driving to more commodity solutions, and standard solutions are being made

IN THE FACE OF A SLOW- TO NO-GROWTH EDA INDUSTRY, SOME VENDORS HAVE MADE THE LEAP OF FAITH THAT A JUMP IN AUTOMOTIVE-ELECTRONICS CONTENT WILL LEAD TO GREATER DEMAND FOR EDA TOOLS.

available that meet many of our needs."

Still, ASICs in the segment grew 6.2%, according to a report from Strategic Analytics, and 9.2%, according to Gartner (**Figure 2**). However, because of reliability and cost constraints and volume, tier-one vendors typically implement ICs in older and more proven process geometries. OEMs would like to see tier-one vendors provide the electronics in more bleeding-edge silicon processes, but EDA software and methodologies aren't reliable and cost-effective enough for most IC vendors to go that route. Today, engineers design most digital ICs for 2008/2009 vehicles using 0.18-micron CMOS. Freescale's PowerPC and Renesas' SH-series microprocessor units use 0.13- and 0.12-micron silicon processes for powertrain ECUs. Engineers probably implemented the most advanced digital chip in the car you are driving today in 0.25-micron CMOS.

In the face of a slow- to no-growth EDA industry, some vendors have made the leap of faith that a jump in automotive-electronics content will lead to greater demand for EDA tools. But the automotive vendors and suppliers say that contention is only partly true, and there won't be a huge demand for more standard IC-design tools. Most chip companies and tier-one suppliers already own the tools to design pc boards and 130-nm ICs. What the industry needs are tools targeting automotive-design problems.

SOC MEANS "SYSTEM ON CAR"

In particular, the industry needs streamlined communications across the three design tiers and for real system-level—system-on-car—design and verification. There is a need for modeling from chip, to ECU, to network levels to allow the OEMs to proactively design a network and the required ECUs with model-based design and software and pass that system-level specification down the design chain.

To date, traditional EDA companies, such as Mentor Graphics and Synopsys, have dabbled in automotive tools. Mentor has for many years offered its VeSys wire-harness tools for routing cables throughout car, airplane, and household-appliance chassis, and Synopsys has for years offered a mechanical-, electrical-, and thermal-simulation tool with Saber. Over the last year, Mentor has also added to its portfolio a multidiscipline simulation tool that allows users to describe signals with standard VHDL-AMS rather than a proprietary language, which Saber uses.

Mentor has seemingly gone one step further, jumping into network design by purchasing Volcano Communications Technologies in May 2005. Mentor's not breaking into new territory with that acquisition nor is Volcano by any means the only game in that area; companies such as Vector-CanTech specialize in automotive-network design and simulation. And companies such as The Mathworks and Vast Systems Technology offer advanced ECU models that take strides in offering OEMs tools to model an entire electrical system and create more precise constraints and derivatives more rapidly.

Volcano and Vector tools attack automotive-network design from opposing angles. Simply put, Volcano requires users to know all their ECU constraints and then allows them to fit networks to the

MORE AT EDN.COM

For more recent articles on the automotive sector, check out:

- www.edn.com/article/CA6251507
- www.edn.com/article/CA6280081
- www.edn.com/article/CA6288052
- www.edn.com/article/CA6263975

USB I/O Unlimited

Simple Connectivity for Measurements in Minutes



More than **20** USB data acquisition modules starting at $95



NI LabVIEW drivers for more than **4,000** USB and GPIB instruments



USB adapters for GPIB and serial instruments



Universal USB device control with USB functions for LabVIEW



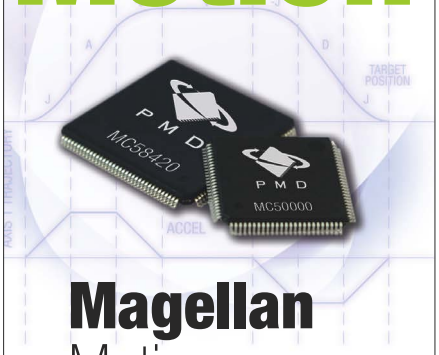
NEW Hi-Speed USB modules with industry's fastest sampling rates

To find the perfect USB device for your system, visit **ni.com/usb**.
(800) 327 9894

NATIONAL INSTRUMENTS™

© 2005 National Instruments Corporation. All rights reserved. LabVIEW, National Instruments, NI, and ni.com are registered trademarks of National Instruments. Other product and company names listed are trademarks or trade names of their respective companies. 2005-6278-301-101-D

Intelligent
Motion



Magellan
Motion
Processors

DC Servo, Brushless DC,
Microstepping, Pulse & Direction

- Advanced IC-based motion controllers
- 1, 2, 3 and 4-axis versions
- S-curve, trapezoidal, velocity contouring, and electronic gearing profiles
- Parallel, CANBus, serial multi-drop host communications
- Programmable PID, dual biquad filters
- 3.3 V operation

DEVELOPER'S KIT AVAILABLE

The Best Engineered Products in Motion

P M D PERFORMANCEMOTIONDEVICES

www.magellan-ic.com

MEDICALAUTOMATION
ROBOTICS
SEMICONDUCTOR

Magellan is a trademark of Performance Motion Devices, Inc. All other trade names, brand names and company names are the property of their respective owners.

© 2005 Performance Motion Devices, Inc.

ECUs. Meanwhile, Vector-CanTech offers bus-network design and simulation into which users plug their ECUs. Both companies support multiple bus standards, including CAN, LIN, and the emerging high-speed-bus protocol, FlexRay.

Vast focuses on offering ECU-hardware modeling, and The Mathworks offers ECU-hardware and -software modeling. Companies such as ETAS Group and Enea focus on software-embedded modeling and design.

Real-time design and testing are imperative in the automotive industry, says Jeff Kessen, director of strategic marketing and communications for ETAS. "An eight-cylinder engine needs fuel-delivery computations nearly 500 times per second at high rpm, while an ABS [antilock-braking system] can adjust braking force more than 10 times per second," he notes.

But it isn't just hardware working with software that requires simulation—it's working with extreme heat conditions and getting bounced around in automobiles over a long period of time. "Some OEMs are now integrating a transmission ECU with the hydraulic control valves, and the ECU is immersed in transmission fluid," says Kessen. "With aggressive driving on a hot day, the fluid can reach 150°C (300°F). The motherboard of a PC could never survive those conditions." That scenario means that a need also exists for EDA vendors to expand or partner with other disciplines—thermal and mechanical and perhaps even fluid-dynamic tool suppliers.

One of the reasons that few electronic tools for automotive exist is that many auto suppliers are secretive (or embarrassed) about their electrical-system design flows and don't wish to participate in joint standards. One of the most promising efforts in standardization is AutoSAR (Automotive Open System Architecture), which promises to help define ECUs and subfunctions in hardware and software that are common to all automobiles. The group has the support of several European auto manufacturers and suppliers and hopes to standardize hardware and software of common functions. Doing so, the group hopes to streamline communications between design tiers and speed automotive-electronic-design cycles. Mentor, through its acquisition of Volcano, has a director's role in AutoSAR, which gives the company more power in influencing the direction of the standard.

Mentor and Synopsys are not the only big EDA companies drawn to the potential opportunity in the automotive industry. Cadence Design Systems in mid-2005 said it is working on a design kit targeting automotive design. It remains to be seen whether the kit will include specialized tools or simply bundle existing IC, pc-board, and package tools at a price attractive to automotive groups within tier-two, tier-one, and automotive companies.

The need for a true system-on-car-level tool is not a new concept for Cadence, EDA's largest vendor. The company had offered a tool, VCC (Virtual Component Co-Design), which turned out in retrospect to be ahead of its time and certainly ahead of the auto industry's need for system-level modeling. EDN

REFERENCE

1 www.reed-electronics.com/moversandshakers/article/CA6277508.

FOR MORE INFORMATION

AutoSAR
www.autosar.org

Cadence Design Systems
www.cadence.com

Enea
www.enea.com

ETAS
http://en.etasgroup.com

FlexRay
www.flexray.org

Freescale
www.freescale.com

General Motors
www.gm.com

Infineon
www.infineon.com

International Rectifier
www.irf.com

The Mathworks
www.mathworks.com

Mentor Graphics
www.mentor.com

NEC
www.necel.com

Philips
www.semiconductors.philips.com

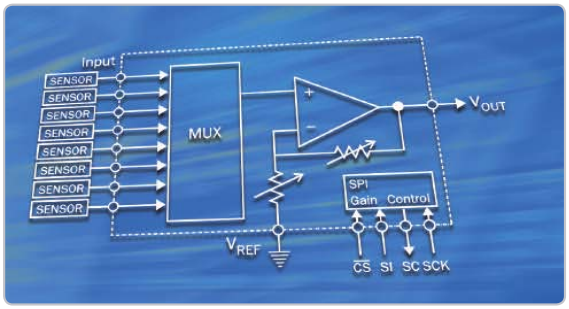
Renesas
www.renesas.com

Synopsys
www.synopsys.com

Vast Systems Technology Corp
www.vastsystems.com

Vector-CanTech
www.vectorcantech.com





Digital Gain Control

Programmable Gain Amplifiers

MCP6S2X Family Features

- SPI™ bus to control gain and select input channel 1, 2, 6 and 8 channel devices
- Gain steps of 1, 2, 4, 5, 8, 10, 16 and 32 V/V
- -3 dB bandwidth of 2 to 12 MHz
- V_{os} <275 µV (max)
- Gain error <1%
- Rail-to-rail input and output
- Low noise: 10 nV √Hz
- Low supply current: 1.1 mA (typical)
- Single supply 2.5V to 5.5V
- Characterized over extended temperature range

www.microchip.com/pga

ALL THINGS ELECTRONIC—START WITH MICROCHIP



Part #	GBWP	IQ Typical (µA)	Vos Max (mV)	Temp. Range (°C)	Features
MCP6275/85/95	2/5/10 MHz	170/230/445	3	-40 to +125	Rail-to-Rail Input/Output, Dual Connected with Chip Select
Selected Standard Op Amps					
MCP6241	650 kHz	50	5	-40 to +125	Rail-to-Rail Input/Output
MCP6271/2/3/4	2 MHz	170	3	-40 to +125	Rail-to-Rail Input/Output
MCP601/2/3/4	2.8 MHz	230	2	-40 to +125	Rail-to-Rail Output
MCP6281/2/3/4	5 MHz	445	3	-40 to +125	Rail-to-Rail Input/Output
MCP6291/2/3/4	10 MHz	1000	3	-40 to +125	Rail-to-Rail Input/Output

Features

- Extended Temperature Range
- Available in PDIP, SOIC, MSOP and TSSOP
- MCP601 and MCP6241 in SOT-23 and SC70

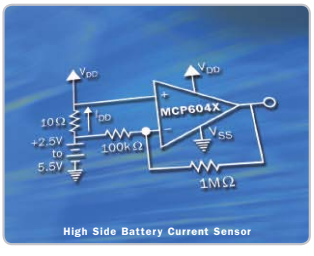
600 nA I_Q

MCP6141/2/3/4 and MCP6041/2/3/4 Features

- Rail-to-Rail Input/Output
- MCP6141/2/3/4: G>10, GBWP 100 kHz
- MCP6041/2/3/4: Unity gain stable, GBWP 14 kHz
- Wide Voltage Range: 1.4V to 5.5V (max)
- Extended Temperature Range -40°C to +125°C
- Available in Single, Dual, Quad
- Wide Supply Voltage Range: 1.4V to 5.5V (max)
- Unity Gain Stable

www.microchip.com/mcp6x4x

Typical Application



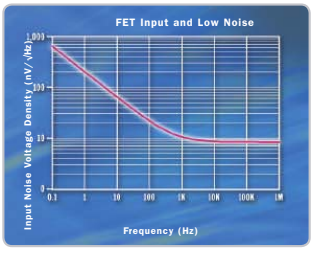
0.5V_{cc} Voltage Reference for Single

MCP6021/2/3/4 Features

- Rail-to-Rail Input/Output
- Wide bandwidth: 10 MHz
- Low noise: 8.7 nV/√Hz
- Low input offset voltage and low distortion (0.00053% THD+N)
- Extended Temperature Range -40°C to +125°C
- V_{os} <500 µV

www.microchip.com/mcp602x

Low Voltage, Low Noise, 10 MHz Op Amps



microchip DIRECT
www.microchipdirect.com
One-stop shopping for MCUs, digital signal controllers, analog and serial EEPROMs.

Now Pb-free!

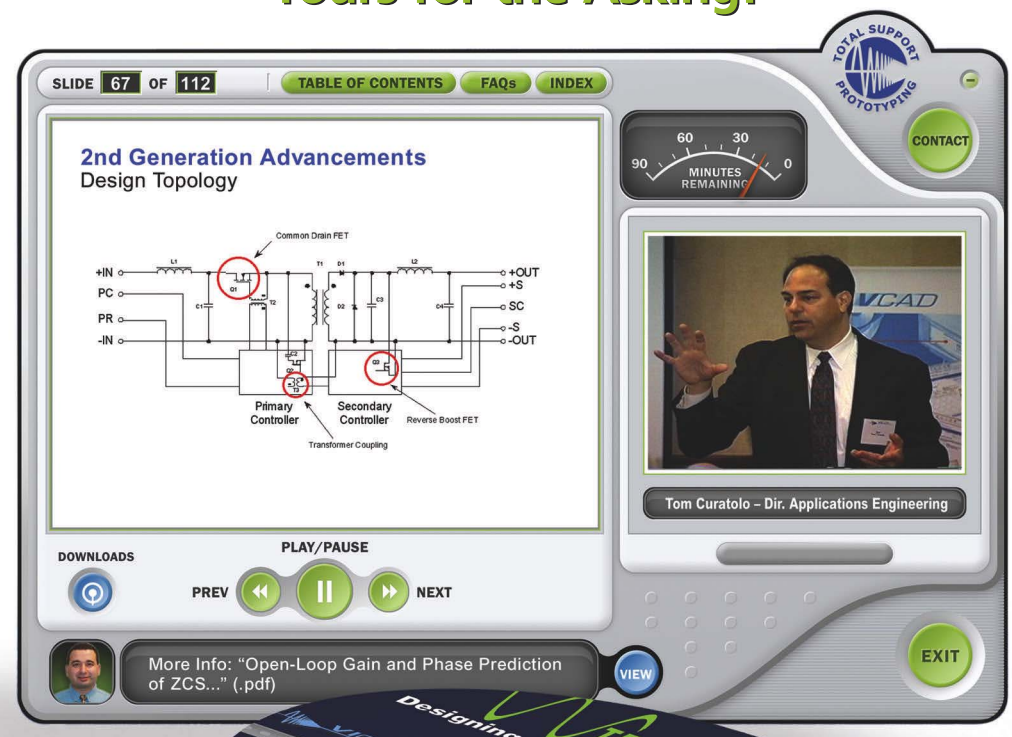
MICROCHIP

www.microchip.com/mcp62x5

The Microchip name and log and the Microchip logo are registered trademarks of Microchip Technology Incorporated in the USA and in other countries. ©2006 Microchip Technology Incorporated. All rights reserved.

A Purely Technical Experience

Yours for the Asking!





TOPICS COVERED

- Zero-current/Zero-voltage Switching Topology
- 2nd Generation Advancements
- Vicor Design Assistance Computer
- Electrical Performance
- Thermal Considerations
- Control Functions
- Unique Paralleling Methods
- Electrical Safety Concepts
- Module Do's and Don'ts
- Mounting Techniques
- Application Examples
- EMI Considerations

"DESIGNING WITH COMPONENT POWER MODULES"

A Technical Seminar on CD

Presented by leading power applications expert, Tom Curatolo, VICOR's CD Seminar is a purely technical 90-minute experience that you can run at your own pace. The CD provides power system designers with an in-depth technical review of issues including electrical, mechanical, and thermal design; EMI, and applications. The information is presented in a synchronized format and includes printed and video back-up materials which are downloadable.



YOURS FOR THE ASKING!

For your complimentary copy of "Designing with Component Power Modules" go to vicorpower.com/cd or contact us at **800-735-6200.**

This is the first in a series of Tech Seminar CDs and by registering now you will be automatically informed as new ones become available.

VICOR

BY CHANGHUA WAN AND JIAN-X ZHENG • ZELAND SOFTWARE INC

Designing RF-IC filters using an automated circuit and layout synthesis

RF-IC DESIGNERS CAN AUTOMATE TEDIOUS FILTER-DESIGN ITERATIONS BY INTEGRATING DESIGN STEPS WITH AN ELECTROMAGNETIC SIMULATOR.

The filters in an RF IC are important elements, affecting the IC's performance, size, and cost. Traditionally, design of RF-IC filters requires three steps: lumped-element circuit synthesis from specifications, layout synthesis of individual circuit elements, and manual assembly and adjustment of individual elements. These steps make the design time-consuming. However, with a fast and accurate EM (electromagnetic) simulator, circuit designers can automate the design of RF-IC filters by combining the three steps in a single integrated design environment.

Challenges do exist. Layout synthesis of spiral inductors and MIM (metal-insulator-metal) capacitors depends on the speed and accuracy of the EM simulator used. Automatic assembly and adjustment of spiral inductors and overlay capacitors require well-defined rules for interconnections, element separation, and input/output arrangement.

AUTOMATING CIRCUIT AND LAYOUT SYNTHESIS

The first step is to electrically synthesize a lumped-element filter according to its specifications. It involves synthesizing a lowpass-filter prototype and transforming the prototype to a desired filter type if the goal is a highpass, bandpass, or bandstop response (**Figure 1**).

The second step is to physically synthesize inductors and capacitors. In RF ICs, a spiral is the best choice for implementing an inductor. For simplicity, this article considers only square spirals. The filter's capacitor can take two forms: a MIM capacitor or an interdigital capacitor. In capacitance value, the MIM capacitor has a larger range than the interdigital capacitor. Therefore, you use MIM capacitors to simplify the automatic synthesis. **Figure 2** illustrates the translation of electrical elements to their physical layout.

You must lay out inductors in such a way that their connections with other inductors and capacitors require minimum chip area. A natural approach to inductor layout is to make input and output traces in parallel. **Figure 3** shows the eight cases corresponding to spirals of two to 2.875 turns with 0.125-turn increments.

The last step is to assemble individual elements in layout format to generate a complete filter. To achieve this goal, the designer needs to specify the distance, d, between two neigh-

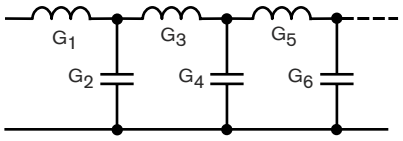


Figure 1 Electrically synthesizing a lumped-element filter according to its specifications involves synthesizing a lowpass-filter prototype and transforming the prototype to a desired filter type.

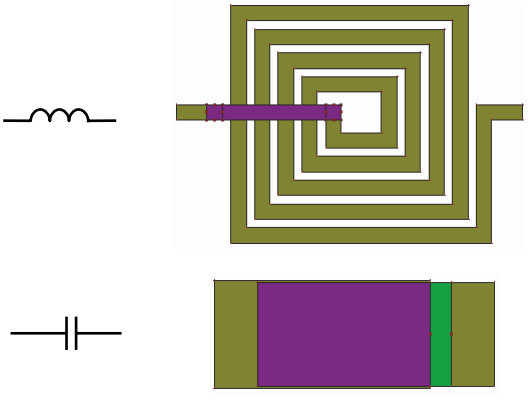


Figure 2 The second step of automating circuit and layout synthesis involves translating an inductor from symbol to layout (a) and translating a capacitor from symbol to layout (b).

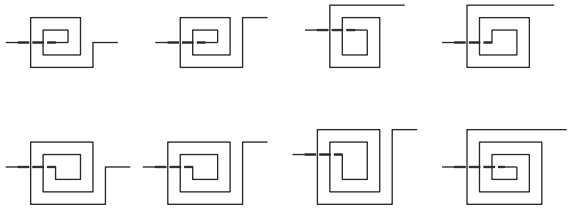
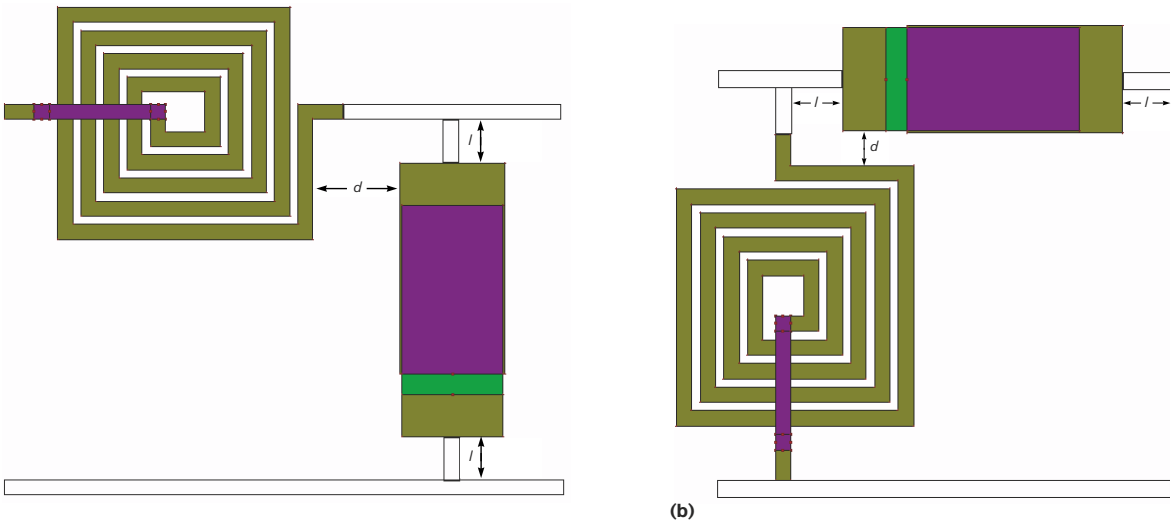
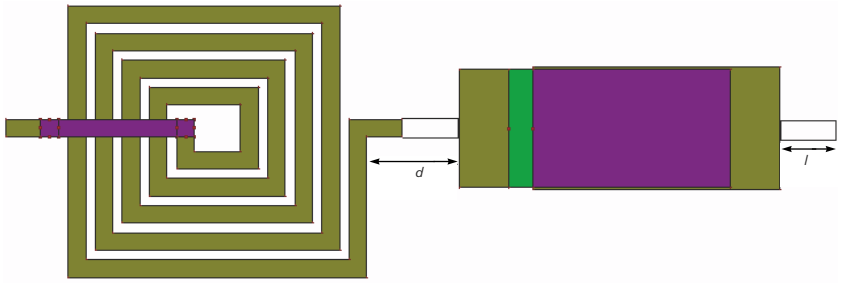


Figure 3 Eight turn-dependent cases of inductor layout correspond to spirals of two to 2.875 turns with 0.125-turn increments.

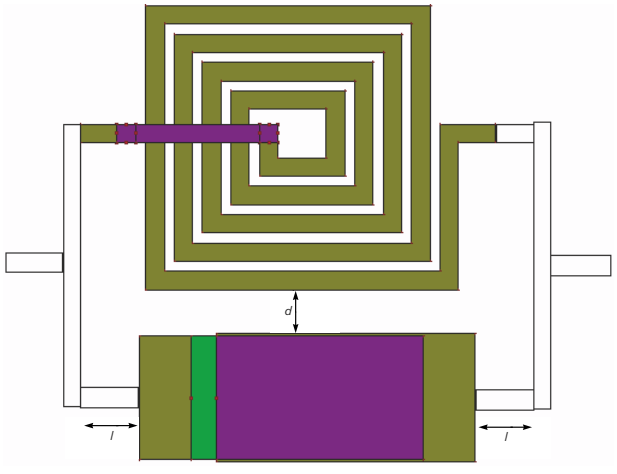


(a) (b)

Figure 4 The LC section may be lowpass (a) or highpass (b).



(a)



(b)

Figure 5 For a series branch, L and C form a bandpass (a) and bandstop (b) combination. For a shunt branch, in contrast, L and C form a bandstop (a) and bandpass (b) combination.

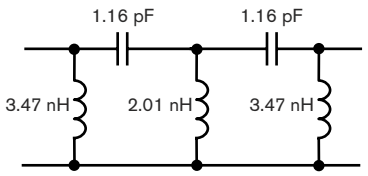


Figure 6 The automatic circuit and layout synthesis for a highpass filter meeting the specifications listed in Table 1 produces these element values of the target highpass filter in lumped-element form.

boring components and the length of a feedline, l, from a component to signal or ground lines or to a junction. **Figure 4a** shows a lowpass LC section, and **Figure 4b** depicts a highpass one.

For bandpass or bandstop filters, a single element from a lowpass-filter prototype translates to a pair of L and C in series or parallel. For a series branch, **figures 5a** and **5b** represent, respectively, a bandpass- and bandstop-LC combination. For a shunt branch, in contrast, **figures 5a** and **5b** represent, respectively, a bandstop- and a bandpass-LC combination as opposed to the case of a series branch.

DESIGN EXAMPLE

A highpass filter is hard to realize in a distributed format in RF- and microwave-frequency bands. The automatic circuit and layout synthesis for a highpass filter meeting the specifications listed in **Table 1** produces the element values of the target highpass filter in lumped-element form in **Figure 6**.

EM-based automatic layout synthesis of the lumped-element highpass filter finds the overlapping length of the MIM capacitor to be 165 microns and the number of turns of the spiral inductors to be 4.875 and 3.875, respectively. With the prescribed distance between adjacent elements and feedline length,

We Take the Heat



100% Tested 150°C Analog ICs

"Under-the-hood" environmental conditions present significant challenges to semiconductors due to temperature extremes, especially in high power devices. Thankfully, Linear's growing family of 150°C junction temperature-capable ICs are tested and guaranteed to perform in this environment. Our products include high voltage monolithic switching regulators, controllers and linear regulators. See the table below for our current offering.

High Junction Temperature Capable ICs

Part No.	V_{IN} Range	Output Current	Topology	$T_{J(MAX)}$°C	Package
LT®3012/3	4V to 80V	250mA	LDO	150	TSSOP-16E
LT3437	3.3V to 80V	400mA	Buck Converter	140	TSSOP-16E
LT1766	5.5V to 60V	1.25A	Buck Converter	140	TSSOP-16E
LT1976	3.3V to 60V	1.25A	Buck Converter	140	TSSOP-16E
LT1936	3.6V to 36V	1.4A	Buck Converter	150	MSOP-8E
LTC®3803-5	6V to 72V	3A	Flyback Controller	150	ThinSOT™
LTC1772	2.5V to 9.8V	5A	Buck Controller	140	ThinSOT
LTC3731	4.5V to 36V	60A	Sync Buck Controller	140	SSOP-36

Info & Free Samples

www.linear.com/automotive
Literature: 1-800-4-LINEAR
Support: 408-432-1900

LEAD-FREE RoHS COMPLIANT

LT, LTC, LT and Burst Mode are registered trademarks and ThinSOT and True Color PWM are trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

LINEAR TECHNOLOGY

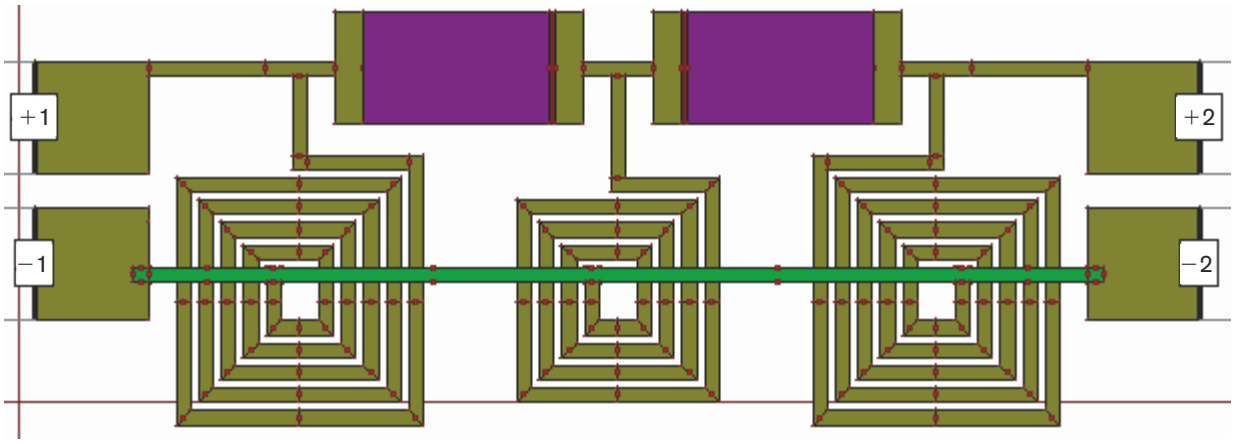


Figure 7 With the prescribed distance between adjacent elements and feedline length, the layout synthesis also automatically assembles all the elements and adds necessary extensions, connections, and pads to produce a complete filter layout.

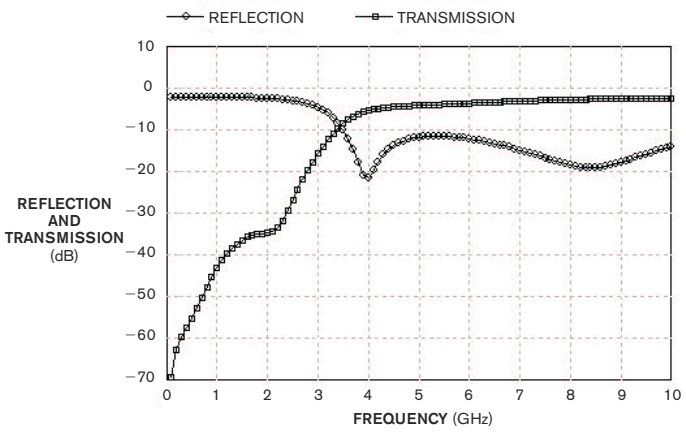


Figure 8 IE3D, a commercial EM simulator, simulates the filter.

the layout synthesis also automatically assembles all the elements and adds necessary extensions, connections, and pads to produce a complete filter layout (**Figure 7**). To suit a particular application, chip area, or both, the final layout may need some minor manual adjustment, but this modification does not alter the effectiveness of the proposed procedure. An adjustment to **Figure 7** makes the ground closer to the signal conductor instead of simple extensions of traces.

IE3D, a commercial EM simulator, simulates the filter (**Figure 8**). The display shows both a highpass response and a significant shift of the cutoff frequency, demonstrating the validity of the design strategy and the power of the tool. The shift is most likely attributable to the interconnections, because the synthesis assumed zero-length interconnects. EDN

MORE AT EDN.COM

We encourage your comments! Go to www.edn.com/ms4167 and click on Feedback Loop to post a comment on this article.

TABLE 1 SPECIFICATIONS FOR EXAMPLE RF HIGHPASS FILTER

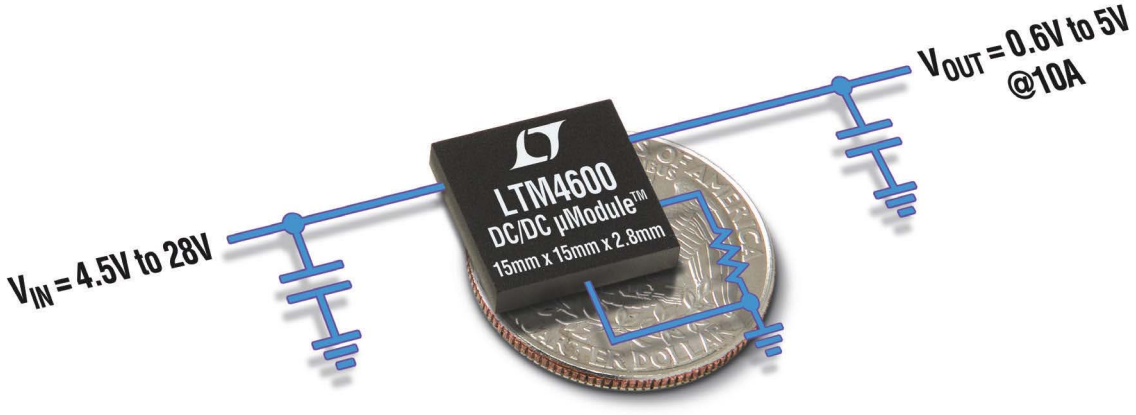
Cutoff frequency	2 GHz
Reference impedance	50Ω
Insertion-loss ripple (Chebyshev)	0.1 dB
Minimum attenuation at and below 1.5 GHz	20 dB
Substrate	500-micron silicon
Oxide	4.5-micron silicon-dioxide
Width of spiral trace	13 microns
Gap between adjacent traces	7 microns
Width of upper MIM-capacitor plate	100 microns
Width of lower MIM-capacitor plate	105 microns
Insulator between capacitor plates	0.5-micron oxide
Distance between adjacent elements	25 microns
Length of feedlines	25 microns

AUTHORS' BIOGRAPHIES

Changhua Wan is a senior R&D engineer at Zeland Software, where he is responsible for developing electromagnetic-simulation and design software. He has a doctorate in electrical engineering from the UESTC (University of Electronic Science and Technology of China). He enjoys camping and skiing.

Jian-X Zheng is the president of Zeland Software, where he is responsible for corporate administration and the definition and development of electromagnetic-simulation and design software. He has a doctorate in electrical engineering from the University of Colorado—Boulder. He enjoys travel.

Instant 10A Power Supply



Complete, Quick & Ready.

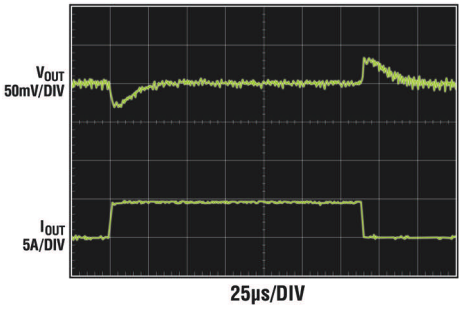
The LTM®4600 is a complete 10A switchmode step-down power supply with a built-in inductor, supporting power components and compensation circuitry. With high integration and synchronous current mode operation, this DC/DC µModule™ delivers high power at high efficiency in a tiny, low profile surface mount package. Supported by Linear Technology's rigorous testing and high reliability processes, the LTM4600 simplifies the design and layout of your next power supply.

Features

- 15mm x 15mm x 2.8mm LGA with 15°C/W Θ_{JA}
- Pb-Free (e^4), RoHS Compliant
- Only C_{BULK} Required
- Standard and High Voltage:
 LTM4600EV: $4.5V \leq V_{IN} \leq 20V$
 LTM4600HVEV: $4.5V \leq V_{IN} \leq 28V$
- $0.6V \leq V_{OUT} \leq 5V$
- I_{OUT}: 10A DC, 14A Peak
- Parallel Two µModules for 20A Output

Ultrafast Transient Response

2% ΔV_{OUT} with a 5A Step



V_{IN} = 12V, V_{OUT} = 1.5V, 0A to 5A Load Step
(C_{OUT} = 3 x 22µF CERAMICS, 470µF POS CAP)

Info & Online Store

www.linear.com/micromodule

Literature: 1-800-4-LINEAR

Support: 408-432-1900



LT, LTC, LT, LTM and PolyPhase are registered trademarks and µModule is a trademark of Linear Technology Corporation. All other trademarks are the property of their respective owners.

LINEAR TECHNOLOGY

14-Bit, 125Msps ADC Only 395mW

	10Msps	25Msps	40Msps	65Msps	80Msps	105Msps	125Msps
14-Bit	LTC2245	LTC2246	LTC2247	LTC2248	LTC2249	LTC2254	LTC2255
12-Bit	LTC2225	LTC2226	LTC2227	LTC2228	LTC2229	LTC2252	LTC2253
10-Bit		LTC2236	LTC2237	LTC2238	LTC2239	LTC2250	LTC2251

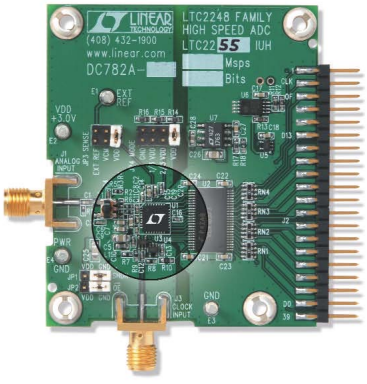
Lowest Noise, Lowest Power, Smallest Solution Size, Pin-Compatible Family

The LTC®2255 family features excellent AC performance with 72.4dB SNR, 88dB SFDR and extremely low power. At just 395mW, the LTC2255 consumes nearly half the power of the competition, benefiting wireless base stations, imaging systems and portable instrumentation where efficiency and cooling are critical. Part of a pin-compatible family in a small 5mm x 5mm QFN package requiring only a few tiny external components, they offer the smallest solution size available.

Features

- Sample Rate: 125Msps/105Msps
- Single 3V Supply (2.85V to 3.4V)
- Low Power: 395mW/320mW
- 72.4dB SNR
- 88dB SFDR
- Clock Duty Cycle Stabilizer
- Pin-Compatible Family in 5mm x 5mm QFN Package

High Speed ADC Evaluation Board



Info & Online Store

www.linear.com

Literature: 1-800-4-LINEAR

Support: 408-432-1900

LT, LTC and LT are registered trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

LINEAR TECHNOLOGY

LINEAR TECHNOLOGY

DESIGN NOTES

Easy Drive™ ADCs Simplify Measurement of High Impedance Sensors – Design Note 379

Mark Thoren

Delta-sigma ADCs, with their high accuracy and high noise immunity, are ideal for directly measuring many types of sensors. Nevertheless, input sampling currents can overwhelm high source impedances or low-bandwidth, micropower signal conditioning circuits. The LTC®2484 family of delta sigma converters solves this problem by balancing the input currents, thus simplifying or eliminating the need for signal conditioning circuits.

A common application for a delta-sigma ADC is thermistor measurement. Figure 1 shows the LTC2484 connections for direct measurement of thermistors up to 100kΩ. Data I/O is through a standard SPI interface and the sampling current in each input is approximately:

$$\frac{\left(\frac{V_{REF}}{2}\right) - V_{CM}}{1.5M\Omega}, \text{ where } V_{CM} = \frac{V_{IN}^{+} + V_{IN}^{-}}{2}$$

or about 1.67μA when V_{REF} is 5V and both inputs are grounded.

Figure 2 shows how to balance the thermistor such that the ADC input current is minimized. If reference resistors R1 and R4 are exactly equal, the input current is zero and no errors result. If the reference resistors have a 1% tolerance, the maximum error in the measured resistance is 1.6Ω due to the slight shift in common mode voltage; far less than the 1% error of the reference resistors themselves. No amplifier is required, making this an ideal solution in micropower applications.

It may be necessary to ground one side of the sensor to reduce noise pickup or simplify wiring if the sensor is remote. The varying common mode voltage produces a 3.5kΩ full-scale error in the measured resistance if this circuit is used without buffering.

Figure 3 shows how to interface a very low power, low bandwidth op amp to the LTC2484. The LT®1494 has excellent DC specs for an amplifier with 1.5μA supply

LT, LTC and LT are registered trademarks and Easy Drive is a trademark of Linear Technology Corporation. All other trademarks are the property of their respective owners.

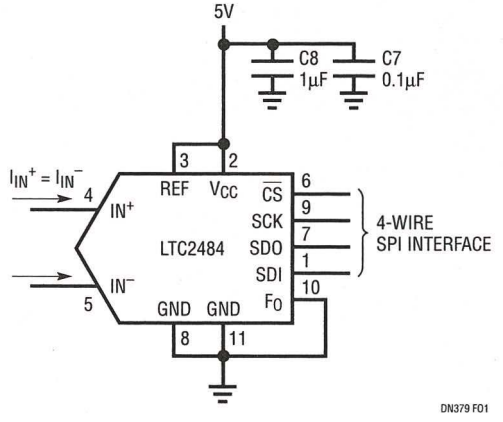


Figure 1. LTC2484 Connections

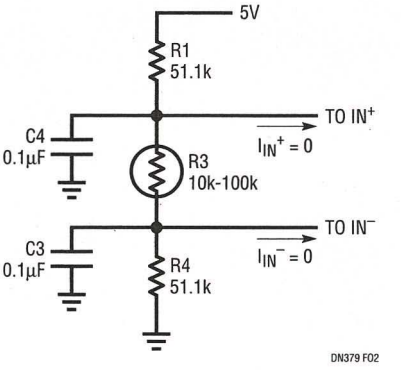


Figure 2. Centered Sensor

current—the maximum offset voltage is 150µV and the open loop gain is 100,000—but its 2kHz bandwidth makes it unsuitable for driving conventional delta-sigma ADCs. Adding a 1kΩ, 0.1µF filter solves this problem by providing a charge reservoir that supplies the LTC2484's instantaneous sampling current, while the 1kΩ resistor isolates the capacitive load from the LT1494. Don't try this with an ordinary delta-sigma ADC—the sampling current from ADCs with specifications similar to the LTC2484 family would result in a 1.4mV offset and a 0.69mV full-scale error in the circuit shown in Figure 3. The LTC2484's balanced input current allows these errors to be easily cancelled by placing an identical filter at IN⁻.

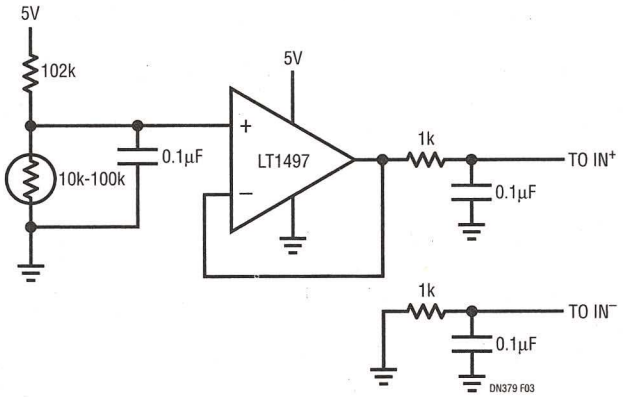


Figure 3. Grounded, Buffered Sensor

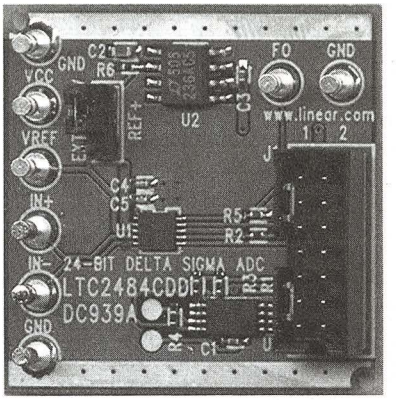


Figure 4. LTC2484 Demo Board

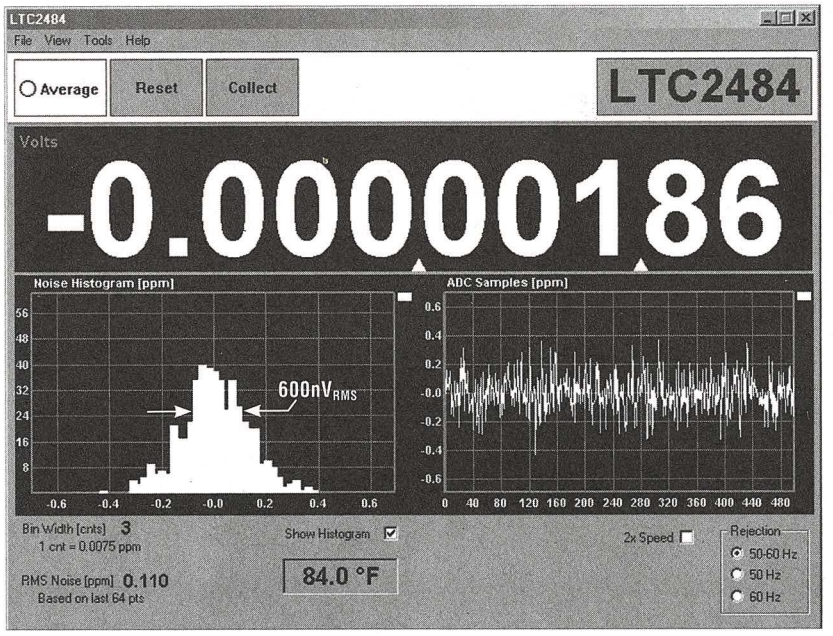


Figure 5. LTC2484 Demo Software Screenshot Showing Microvolt Offset and 600nV$_{RMS}$ Noise

Data Sheet Download

http://www.linear.com

For applications help,
call (408) 432-1900, Ext. 2453

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

dn379 LT/TP 1205 305K • PRINTED IN THE USA

© LINEAR TECHNOLOGY CORPORATION 2005

EDITED BY BRAD THOMPSON
AND FRAN GRANVILLE

designideas

READERS SOLVE DESIGN PROBLEMS

CMOS inverters convert RF to digital signal

Francis Rodes, Eliane Garnier, and Guillaume Zingone,
ENSEIRB, Talence, France

Applications ranging from frequency counting and synthesis to sensor signal conditioning require conversion of RF signals to digital-logic levels. In such situations, designers typically use a high-speed voltage comparator to perform the RF-to-digital conversion. Due to their high gain, voltage comparators typically exhibit good sensitivity but also present some drawbacks. High-speed comparators are expensive, difficult to find off the shelf, and prone to rapid obsolescence.

For frequencies as high as 180 MHz, the circuit in **Figure 1** offers an attractive approach. The IC in the design, a 74LVCU04 very-high-speed CMOS hex inverter, is available off the shelf and from many sources. Furthermore, many applications may already include three unused inverters. A single inverter, IC_{1A}, operating as a linear preamplifier, forms the converter's input stage. Biasing resistor R_3 forces the inverter into its linear region by equalizing its input and output voltages at one-half of the power-supply voltage, $V_{O1}=V_{I1}=(V_{DD}/2)$. Because the ac gain of a very-high-speed CMOS inverter is relatively low at RF (V_{O1}/V_{I1})≈7, additional gain stages follow the preamplifier. One self-evident approach—a cascade of additional inverters—presents poor stability at low frequencies and at dc when no RF source is present.

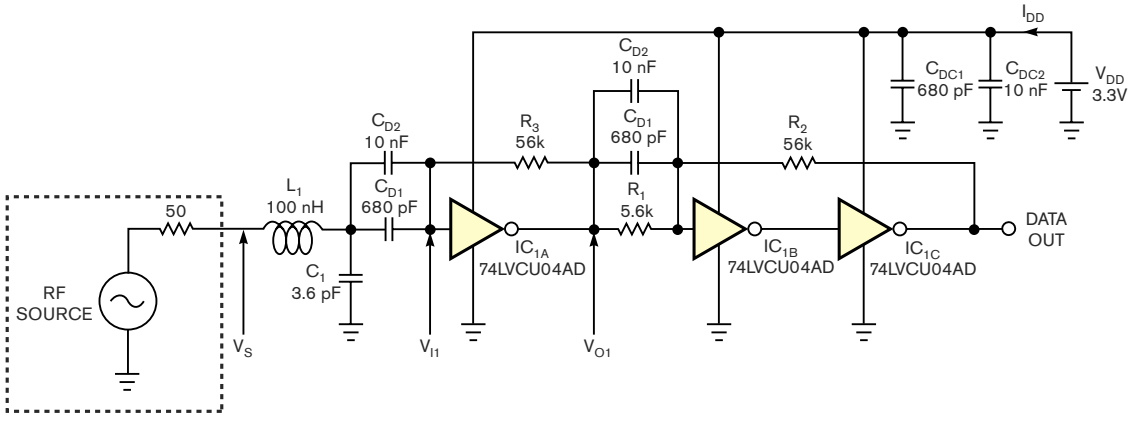
The circuit in **Figure 1** eliminates this drawback thanks to a topology based on a Schmitt trigger and amplifier circuit, IC_{1B} and IC_{1C}, that includes a frequency-dependent positive-feedback network comprising R_1, R_2, C_{D1}, and C_{D2}. Depending on the input frequency, the network exhibits two behaviors: At high frequencies, the decoupling-capacitor pair, C_{DC1} and C_{DC2}, short-circuits feedback resistor R_1, canceling the time constant introduced by the positive-feedback network, R_1 and R_2, and the input capacitance of inverter IC_{1B}. Consequently, at high frequencies, the three inverters, IC_{1A}, IC_{1B}, and IC_{1C}, behave as three cascaded, high-speed amplifiers that allow the best performance in input-signal bandwidth. At dc and low frequencies, the influence of coupling-capacitor pairs C_{D1} and C_{D2} is negligible, and inverters IC_{1B} and IC_{1C} and the positive-feedback network, R_1 and R_2, act as a Schmitt-trigger circuit. The choice of the high- and low-threshold voltages, V_{TH} and V_{TL}, at the Schmitt

DIs Inside

82 Instrumentation amplifier extends DSO

84 Virtual instrument determines magnetic core's B-H-loop characteristics

▶ What are your design problems and solutions? Publish them here and receive $150! Send your Design Ideas to edndesignideas@reedbusiness.com.



NOTE:
ALL COMPONENTS ARE SURFACE-MOUNTED DEVICES.

Figure 1 Three high-speed CMOS inverters and a few passive components form an RF-to-logic converter.

trigger's input, V_{OI}, stems from a compromise between input sensitivity at V_S and ensuring unconditional stability of the comparator's output. **Equations 1** and **2** set the high and low threshold voltages, respectively:

$$V_{TH} = \frac{V_{DD}}{2}\left(1+\frac{R_1}{R_2}\right) \approx 1.8V. \quad (1)$$

$$V_{TL} = \frac{V_{DD}}{2}\left(1-\frac{R_1}{R_2}\right) \approx 1.5V. \quad (2)$$

To counteract a roll-off of sensitivity at higher frequencies, add a low-Q impedance-matching network comprising L_1 and C_1 at the comparator's input. Given the design objective of obtaining acceptable sensitivity at frequencies as high as 160 MHz, the network matches the 50Ω RF source and IC_{1A}'s input impedance, Z_{I1}, at 150 MHz. Unfortunately, manufacturers of digital ICs typically do not specify logic devices' input impedances. When designing the matching network, the first task involves using an Agilent (www.agilent.com) vector-network analyzer to measure the first inverter's input scattering parameter, S_{11}, at IC_{1A}'s input, V_{I1}. **Figure 2** shows a Smith-chart plot of the inverter's S_{11} parameter.

Knowing that

$$S_{11} = \frac{Z_{I1}-Z_C}{Z_{I1}+Z_C}, \quad (3)$$

with Z_C=50Ω, you can use the data in **Figure 2** to extract the first inverter's input impedance at the frequency of interest. At 150 MHz, this yields Z_{I1}= 106.1Ω − j 116.7Ω (at Marker 4 in **Figure 2**). To determine values for the matching network's components, you can use any of several software tools (**references 1** and **2**). If you are unfamiliar with Smith-chart computations, you can also proceed analytically with the following method:

1. Use series-to-parallel transformation formulas (**equations 4** and **5**) to transform the first inverter's input impedance into a parallel form:

$$R_P = \frac{R_S^2 + X_S^2}{R_S}. \quad (4)$$

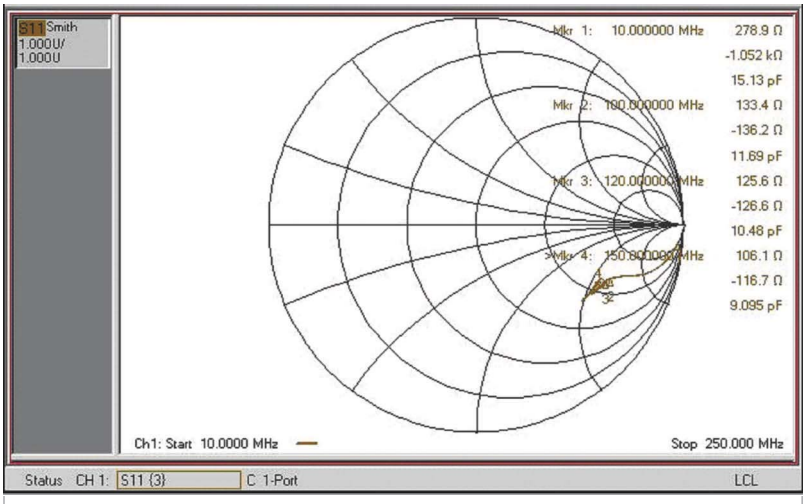


Figure 2 An Agilent N3382A vector-network analyzer obtained this S-parameter plot, which shows S_{11} measured at the first inverter's input for a source power level of −6 dBm.

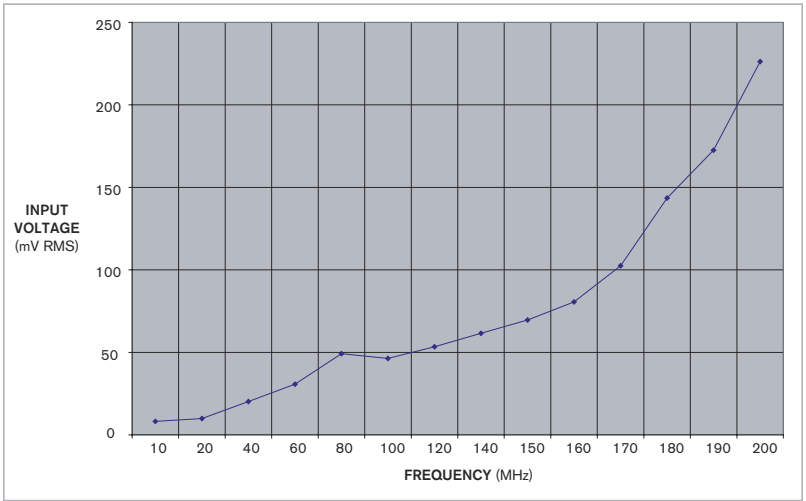


Figure 3 An input-level-versus-frequency plot of the RF-to-digital comparator measured from the RF source's reference plane to a clean logic output reveals less-than-100-mV sensitivity at 160 MHz and usable output to 200 MHz.

$$X_P = \frac{R_S^2 + X_S^2}{X_S}. \quad (5)$$

Applying these formulas at 150 MHz yields: R_p=233Ω, and X_p=−213Ω. (At 150 MHz, X_p represents an input capacitance, C_p=5 pF.)

2. Compute an initial version of the matching network to perform a match between the real part of the first inverter's input impedance, R_p, and the 50Ω RF source. Solving **equations 6** and **7** yields values for the matching network's elements (**Reference 3**):

$$L_1 = \frac{R_S}{\omega}\sqrt{\frac{R_P}{R_S}-1}. \quad (6)$$

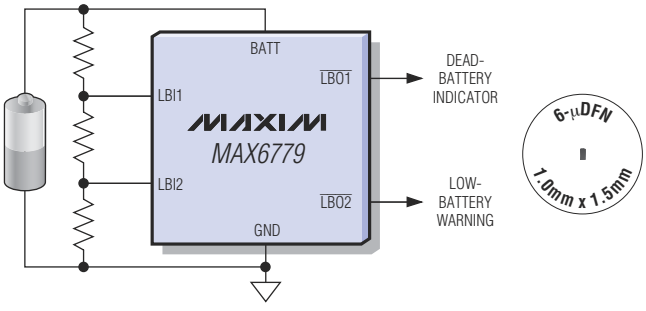
$$C_1 + C_P = \frac{1}{R_P\omega}\sqrt{\frac{R_P}{R_S}-1}. \quad (7)$$

WORLD'S SMALLEST, MOST ACCURATE BATTERY MONITORS MAXIMIZE BATTERY LIFE IN PORTABLE EQUIPMENT

With 1% threshold accuracy, the MAX6775–MAX6781 allow batteries to operate down to their lowest level, thereby maximizing operating time. These miniature ICs are the first battery monitors offered in a 1mm x 1.5mm µDFN package.

Advantages Over the Competition

- ♦ 64% Smaller (µDFN vs. SC70)
- ♦ 42% More Accurate Threshold (1% vs. 1.75% over Temperature)
- ♦ Fixed or Adjustable Hysteresis
- ♦ Single- or Dual-Level Monitoring



Ideal for Portable Applications


GLUCOSE METERS


PDAs


MP3 PLAYERS


GPS


CELLULAR PHONES

Part	Low-Battery Outputs	Threshold Accuracy (%)	Hysteresis (%)	Supply Current (µA)	Package
MAX6775/MAX6776	Single	1	0.5, 5, or 10	3	6-µDFN/5-SC70
MAX6777/MAX6778	Single	1	Adj	3	6-µDFN/5-SC70
MAX6779/MAX6780/MAX6781	Dual	1	0.5, 5, or 10	3	6-µDFN/5-SC70

MAXIM

www.maxim-ic.com

FREE* Battery Management Design Guide—*Sent Within 24 Hours!

CALL TOLL FREE 1-800-998-8800 (6:00 a.m.–6:00 p.m. PT)
For a Design Guide or Free Sample

MAXIM/DALLAS DIRECT! DISTRIBUTION
1-888-MAXIM-IC

ARROW ELECTRONICS, INC.
1-800-777-2776

AVNET electronics marketing
1-800-332-8638

Distributed by Maxim/Dallas Direct!, Arrow, Avnet Electronics Marketing, Digi-Key, and Newark.

The Maxim logo is a registered trademark of Maxim Integrated Products, Inc. The Dallas Semiconductor logo is a registered trademark of Dallas Semiconductor Corp.
© 2006 Maxim Integrated Products, Inc. All rights reserved.

Applying these formulas at 150 MHz yields $L_1 \approx 100$ nH, and $C_1 + C_P \approx 8.7$ pF.

3. Subtract the inverter's input capacitance, $C_P = 5$ pF, from **Equation 7** to calculate a value for C_1:

$$C_1 = \frac{1}{R_P \omega \sqrt{\frac{R_P}{R_S} - 1}} - C_P \approx 3.7 \text{ pF}. \quad (8)$$

To build the circuit, use standard component values that fall closest to the computed values: $L_1 = 100$ nH, and $C_1 = 3.6$ pF. As the plot of input frequency versus sensitivity in **Figure 3** shows, the circuit's increased sensitivity for 100- to 170-MHz frequencies clearly demonstrates the impedance-matching network's effectiveness. You can optimize the circuit's sensitivity in any other frequency band of interest by applying this method at the chosen frequency. The RF-to-digital-logic converter's power consumption does not change significantly for input signals of 10 to 180 MHz. Under worst-case conditions, the current drain does not exceed 58 mA for a supply voltage of 3.3V. EDN

REFERENCES

1. Smith tool, Ansoft Corp, www.ansoft.com.
2. *Ansoft Designer: Student Version*, Ansoft Corp, www.ansoft.com.
3. Bowick, Chris, *RF Circuit Design*, HW Sams & Co, Indianapolis, IN, 1988.

Instrumentation amplifier extends DSO

Bob Perrin, Sacramento, CA

To determine the specifications of a solar-generating plant, I needed to accurately measure the load current a product consumed. The product switched several internal devices on and off during an interval of several seconds. An ammeter showed that the current transitions occurred too quickly for visual logging, and my managers had requested an oscilloscope photo of the current waveform's peaks. I rolled out our company's cart-mounted DSO (digital-storage oscilloscope), inserted a low-value resistor in series with the product's positive-power-supply input, and attempted to make a differential-voltage measurement (Channel A minus Channel B) across the current-sampling resistor.

Unfortunately, RF noise from a local FM-broadcast station swamped the small-load-induced fluctuations in the voltage developed across the sampling resistor, and increasing its resistance

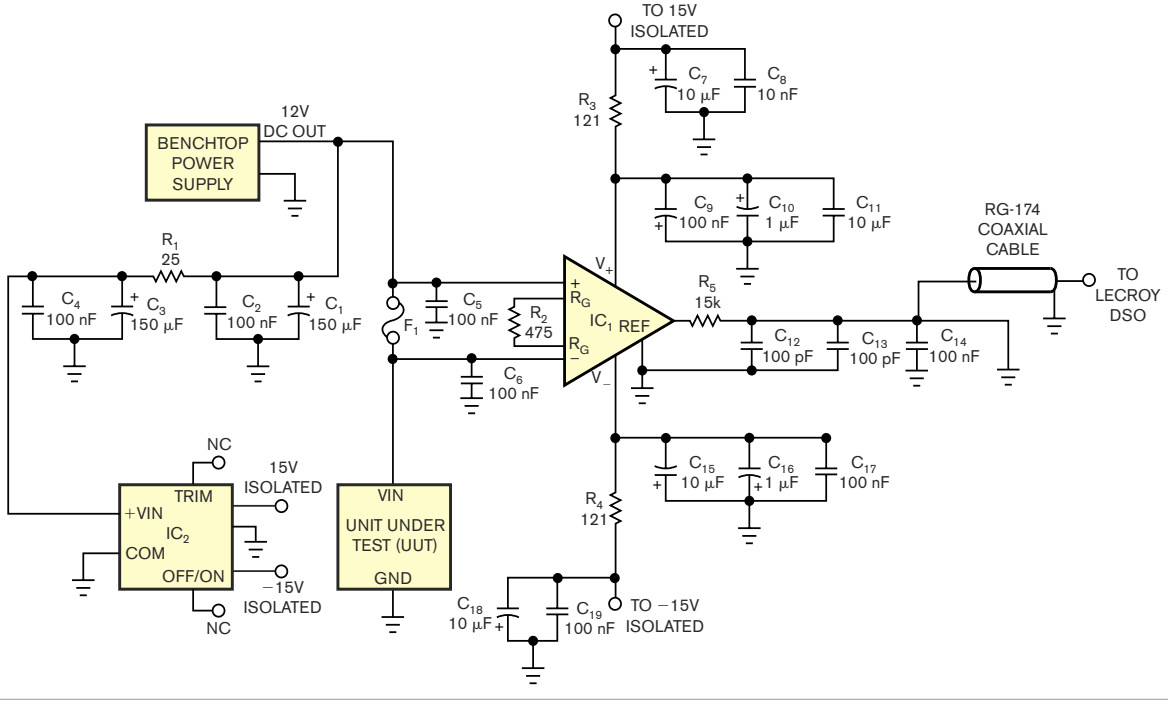
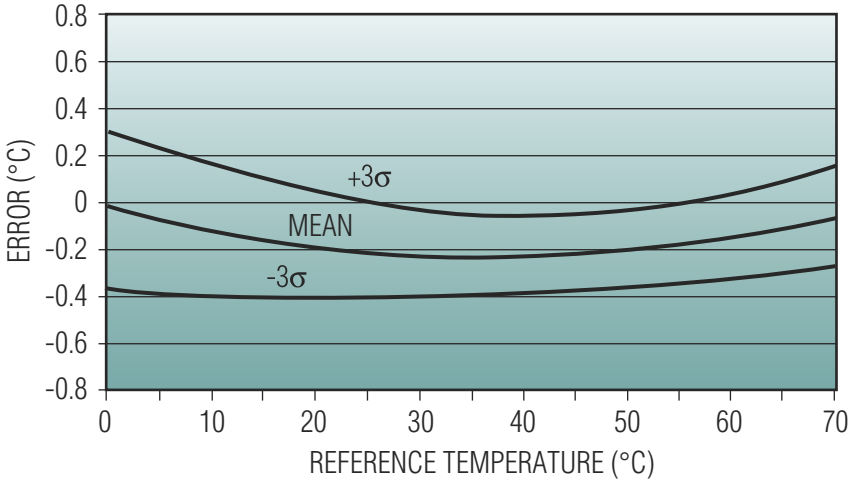


Figure 1 Improve your oscilloscope's performance in high-RF-noise environments by adding an instrumentation-amplifier front end. For best results, package the circuitry in a metal enclosure.

ONLY ONE DIGITAL TEMP SENSOR OFFERS ±0.5°C ACCURACY AND 1.7V TO 3.5V OPERATION

The DS620 is ideal for low-power, battery-operated applications that require precise thermal regulation in a low-voltage environment. Supporting an industry-standard 2-wire interface, design-in is simple. With nonvolatile configuration and user-defined data storage, programming is easy. Typical applications include portable temperature loggers, portable medical equipment, networking equipment, servers and computers, test equipment, and any thermally sensitive system.

±0.5°C ACCURACY OVER TEMPERATURE AND VOLTAGE





- Operates from 1.7V to 3.5V Supply
- Measures Temperature from -55°C to +125°C
- ±0.5°C Accuracy from 0°C to +70°C
- User-Selectable 10-, 11-, 12-, or 13-Bit Resolution
- 4 Bytes of EEPROM Memory for Thermostat Settings
- 4 Bytes of EEPROM Memory for General-Purpose Use
- Configurable as a Stand-Alone Thermostat
- 8-Pin µSOP

DALLAS SEMICONDUCTOR MAXIM

www.maxim-ic.com

FREE* Temperature Sensors Design Guide—*Sent Within 24 Hours!

CALL TOLL FREE 1-800-998-8800 (6:00 a.m.–6:00 p.m. PT)
For a Design Guide or Free Sample

MAXIM/DALLAS DIRECT! DISTRIBUTION
1-888-MAXIM-IC

ARROW ELECTRONICS, INC.
1-800-777-2776

AVNET electronics marketing
1-800-332-8638

Distributed by Maxim/Dallas Direct!, Arrow, Avnet Electronics Marketing, Digi-Key, and Newark.

The Maxim logo is a registered trademark of Maxim Integrated Products, Inc. The Dallas Semiconductor logo is a registered trademark of Dallas Semiconductor Corp.
© 2006 Maxim Integrated Products, Inc. All rights reserved.

introduced an unwanted voltage drop on the product's power-supply rail. Finally, the 12V supply rail introduced a voltage offset that limited the oscilloscope's ability to accurately resolve the small differential signal that I was attempting to measure. I disconnected the oscilloscope's ac ground to "float" the scope with respect to the sampling resistor, but the RF noise visible on the trace increased significantly. I briefly considered using an older analog (nonstorage) scope, but the DSO's storage feature would allow me to capture and print the waveforms required for my report.

In frustration, I scoured the workbench for stray parts and assembled a circuit that solved the problem. By chance, the parts collection included an instrumentation amplifier, IC_1, which does an excellent job of extracting small signals from high-frequency background noise. The amplifier's inherently slow response attenuates RF noise but doesn't affect amplification of lower frequency signals. Adding RC lowpass filters to the amplifier's inputs and output further attenuates lower frequency noise induced by nearby switched-mode power supplies and digital logic or microprocessors.

Normally, I avoid using noise-emitting dc/dc converters as power supplies for analog circuits. However, in this case, IC_2, a dc/dc converter, provided an expedient and technically sound approach (**Figure 1**). In general, dc/dc converters produce more noise as their load currents increase, but, in this circuit, the sole load comprises the instrumentation amplifier that draws only a few milliamperes. Adding a few filtering components provided additional noise suppression.

Under normal operation, the current that the product draws fluctuates from approximately 300 to 800 mA. To minimize the voltage drop induced in the power-supply loop, I used a 5×20-mm, 10A, 250V fuse, F_1, as a current-sampling resistor. Voltage drop across the fuse is approximately 1 mV per 100 mA of current, and operating the fuse at a small fraction of its nominal rating avoids introducing nonlinearities in the measurement.

With a 475Ω gain-setting resistor, R_2, the instrumentation amplifier, an Analog Devices (www.analog.com) AD620, provides a gain of 105V/V and delivers an output of approximately 1V, which corresponds to 1A of current flowing through the shunt. Capacitors C_{12} and C_{13} provide low-impedance paths for high-frequency noise. EDN

Virtual instrument determines magnetic core's B-H-loop characteristics

Michael Nasab, Circuit Mentor, Boulder Creek, CA

To design an inductive component that contains a magnetic-core material, an engineer must accurately measure the material's characteristics. A magnetic core's dynamic hysteresis loop, or "B-H curve," contains valuable information about core losses and other magnetic parameters. Unfortunately, commercially available magnetic-loop-analysis instruments are expensive and thus impractical for small-scale research labs and manufacturers. This Design Idea describes a virtual instrument that uses a desktop or notebook computer with an analog data-acquisition card and National Instruments' (www.ni.com) LabView software (Version 7.1 or above). In operation, the software extracts B-H-loop information, core losses, and other magnetic parameters at a reasonable cost per measurement.

Figure 1 shows the test fixture for a magnetic-core-based device. The device, T_1, comprises a sample of core material and two windings with equal numbers of turns. A precision current-sensing resistor, R_1, samples the excitation current that induces a magnetic field in the core. The voltage drop across R_1 is proportional to the excitation current and the magnetic field, H. A network comprising resistor R_2 and capacitor C_1 integrates the voltage induced in the secondary winding. The voltage across C_1 is directly proportional to the flux density, B, in the core. In practice, R_2's value should be much larger than capacitor C_1's impedance at the operating frequency. (Textbook descriptions of the circuit suggest a ratio of 100-to-1.)

Components' tolerances and characteristics affect measurement accuracy. Use a noninductive, 1Ω, 1%-tolerance resistor of appropriate wattage rating for R_1, and select a low-leakage, low-dielectric-absorption, polyester- or polypropylene-film capacitor with tight tolerance for C_1. To acquire and view the data, you can use a dedicated virtual instrument using a National Instruments PCI-6024E data-acquisition card and LabView. The software features NI's Express VI (virtual-instrument) technology that greatly simplifies the creation of user-designed data-acquisition and -manipulation features. This application uses only two

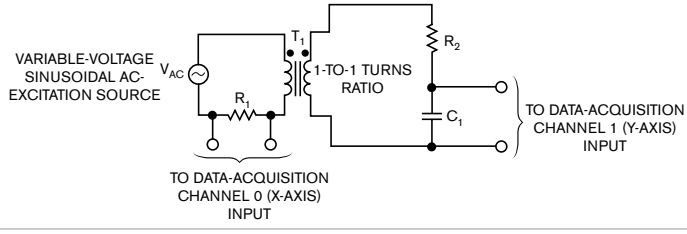


Figure 1 The test fixture for a basic hysteresis-loop analyzer requires few components.

Intersil Battery Charger ICs

Intersil High Performance Analog

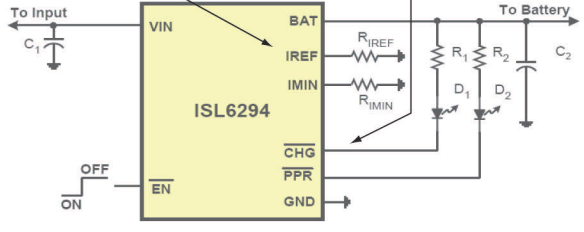
Have **YOU** Seen the World's Smallest Battery Charger IC?

Not only is the 2mm x 3mm ISL6294 the industry's smallest, but this fully integrated, single-cell Li-Ion / Li-Polymer battery charger IC can handle input voltages up to 28V, eliminating the need for an over-voltage protection circuit.

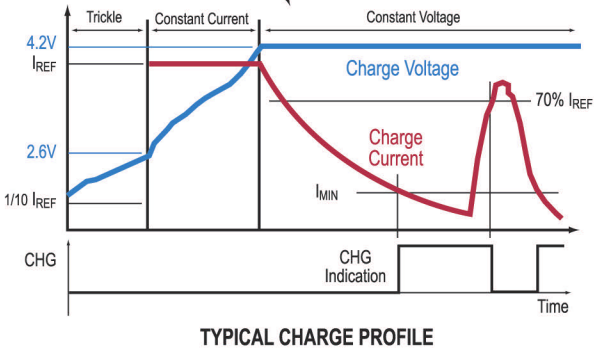


The constant current I_{REF} is set with the external resistor R_{IREF}. The constant voltage is fixed at 4.2V.

End-of-charge (EOC) current indicated through the CHG pin (which can be interfaced to a micro processor), but the charger continues to output the 4.2V.



If the battery voltage is below 2.6V the ISL6294 charges the battery with a trickle current of one-tenth of I_{REF}. When the battery voltage reaches 4.2V, the charger enters a CV mode and regulates to fully charge battery without the risk of over charge.



TYPICAL CHARGE PROFILE

Key Features:

- 2mm x 3mm 8 Ld DFN package
- 28V maximum input voltage
- Programmable end-of-charge current with status interfaced to a micro device through CHG pin
- Thermaguard™ charge current thermal foldback for thermal protection
- No external blocking diode required
- Integrated pass element and current sensor
- 1% voltage accuracy
- Trickle charge for fully discharged batteries
- Less than 1µA leakage current off the battery when no input power attached or charger disabled
- Input over-voltage protection
- End-of-charge indication with large hysteresis to prevent unwanted re-charge

Datasheet, free samples, and more information available at **www.intersil.com/edn**

Intersil – Switching Regulators for precise power delivery.

©2005 Intersil Americas Inc. All rights reserved. The following are trademarks or services marks owned by Intersil Corporation or one of its subsidiaries, and may be registered in the USA and/or other countries: Intersil (and design) and i (and design).

intersil®
HIGH PERFORMANCE ANALOG

data-acquisition analog-input channels: Channel 0 acquires magnetic-field readings (H) for display on an x-y chart's x axis in units of ampere-turns per meter, and Channel 1 captures flux density (B) in tesla units for the y-axis display.

At low frequencies, the core's hysteresis losses predominate, whereas eddy-current losses become more apparent at higher frequencies. A wattmeter-style algorithm calculates core losses, but you can easily substitute your own mathematical expression into the VI block diagram's formula node. LabView also can save the data and export results in Microsoft's (www.microsoft.com) Excel-spreadsheet format or into other programs for further analysis.

You can use another of the data-acquisition card's eight differential analog-input channels to determine inductance. To do so, measure the voltage across the device's primary winding and calculate its rms value. The ratio of the voltage to the rms current as measured through R_1 determines the magnitude of the winding's scalar impedance, X_L. Then, you can calculate the inductance from the following equation: $L=X_L/2\pi f$, where f denotes the frequency of the applied excitation voltage.

Figure 2 shows a hysteresis curve for a 3B7-mixture ferrite-pot core prepared with 100-turn primary and secondary windings and measured at 60 Hz. For comparison, **Figure 3** displays the 60-Hz hysteresis curve for a 100W power transformer wound on a toroidal core composed of grain-oriented steel. The toroidal core's wider loop indicates greater hysteresis, a characteristic that saturable-core power inverters exploit. To apply 60-Hz excitation, you can drive the device's primary winding from a stepdown (isolation) transformer powered by an adjustable-output autotransformer, such as a GenRad (www.ietlabs.com) Variac. While observing the B-H curve display, gradually increase the primary voltage until the flattening of the hysteresis loop's upper and lower portions indicates core saturation. No calibration is necessary if you use precision. However, when evaluating core materials, you may need to experiment with different numbers of turns to obtain the windings' ampere-turns value for optimum results.

For tests at 60 Hz, use a 267-kΩ, 1%-tolerance resistor for R_2 and a 1-µF polyester-dielectric capacitor for C_1 in the integrator network. Depending on the number of turns and the current necessary to obtain a usable output voltage, a few volts of ac excitation is usually sufficient to run the test. For core measurements at higher frequencies, use a signal generator connected to a power amplifier and alter the RC integrator's component values for proper operation at the frequency of interest. Although the application does not use an analog output from the data-acquisition card, this output can serve as a sinusoidal-signal source for the power amplifier.

Review the electrical specifications of the card you plan to use and avoid exceeding the card's peak-to-peak differential- and common-mode input voltages. If the excitation voltage approaches or exceeds the card's ratings, add a 10-to-1 resistive-voltage divider to limit the applied voltage and compensate for the attenuator's losses by adding a factor-of-10 gain multiplier in the software.

You can download a copy of the VI that this Design Idea describes from www.circuitmentor.com/services.htm. You can also obtain a trial version of LabView from NI's Web site at www.ni.com. EDN

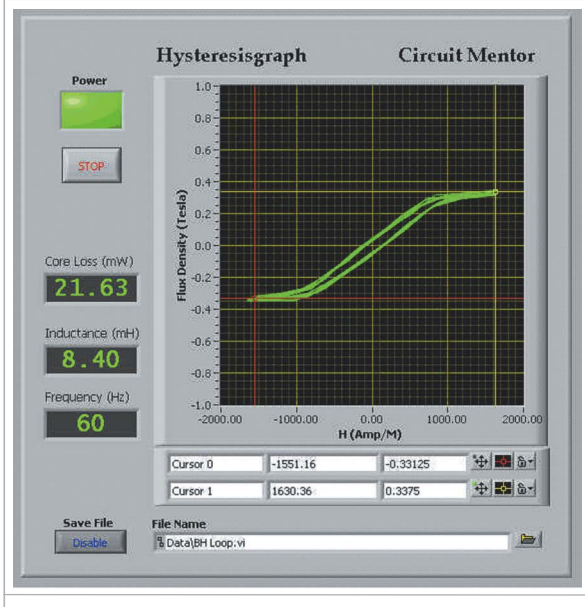


Figure 2 The virtual instrument's display shows a 3B7-mixture ferrite-pot core's B-H loop.

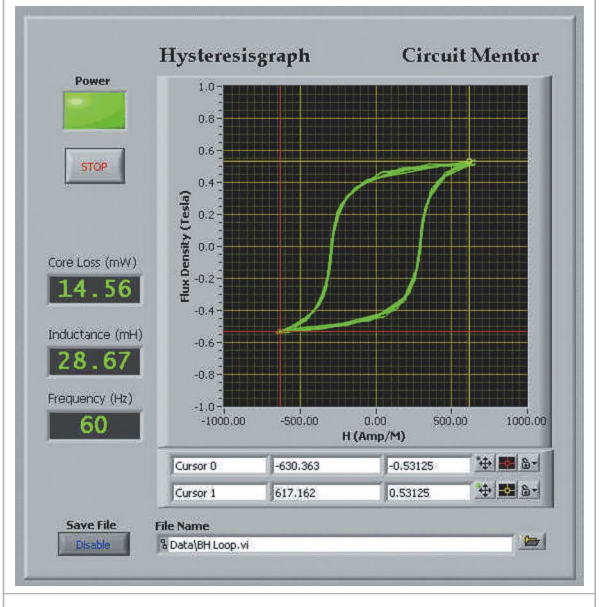
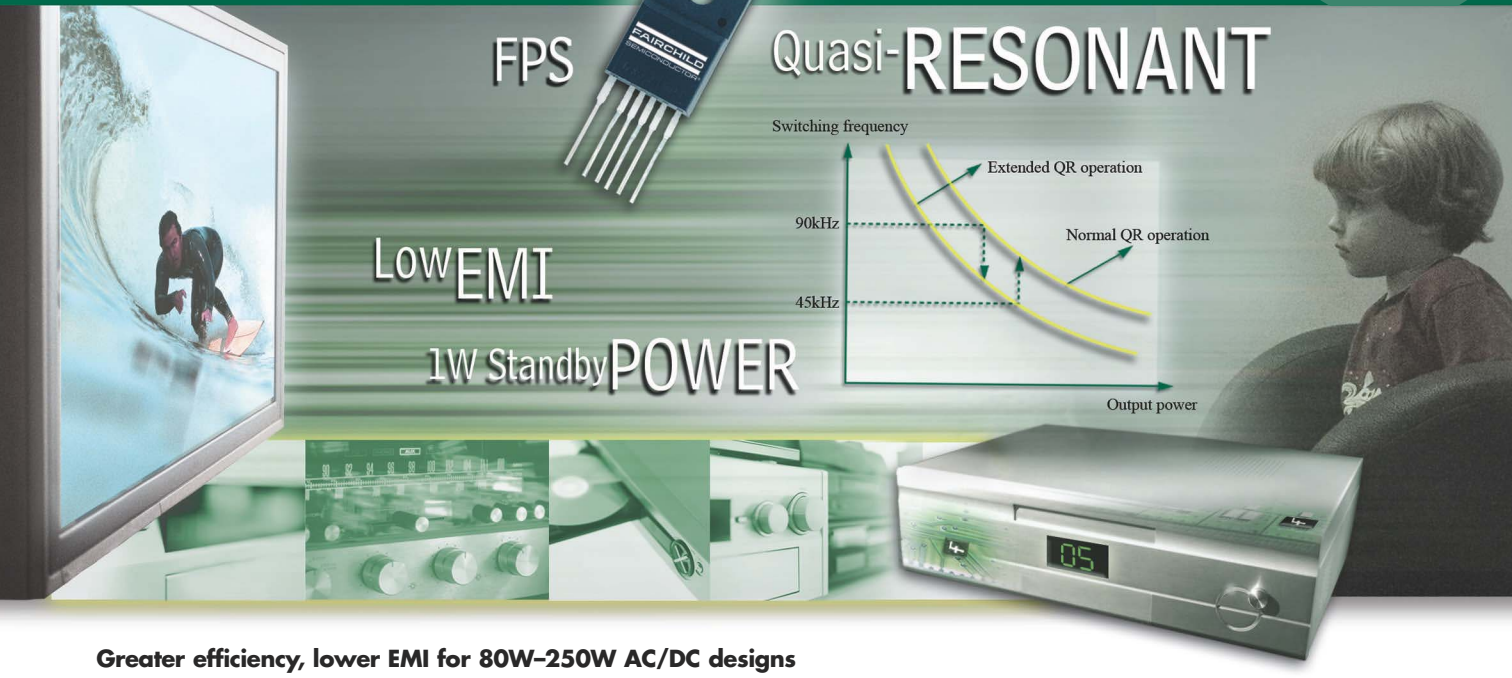


Figure 3 This grain-oriented-steel toroidal core's B-H loop exhibits saturation at a lower excitation value than the core in Figure 2.

FAIRCHILD
SEMICONDUCTOR®

Complete QRC SMPS. Completely Fairchild.



Greater efficiency, lower EMI for 80W–250W AC/DC designs

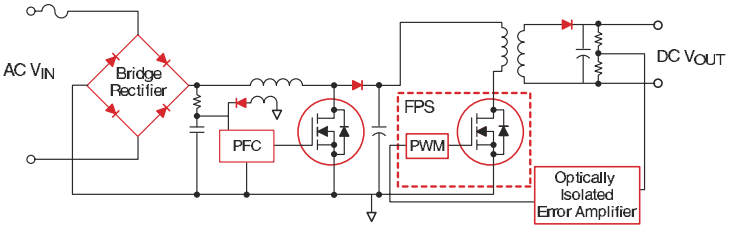
For power supply designs in noise-sensitive applications, choose Green Fairchild Power Switch (FPS™):

- Optimized for quasi-resonant converters (QRC)
- Integrated PWM and avalanche-rugged SenseFET
- Advanced burst-mode operation for under 1W standby power consumption

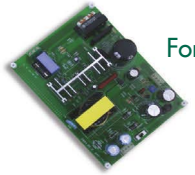
You'll see greater efficiency, with fewer parts, using Fairchild's QRC SMPS solutions.

Part Number	$P_{O(MAX)}$ (W) 85-265V_{AC}	Peak Current Limit (A)	$R_{DS(ON)}$ Max (Ω)
FSCQ0565RT	60	3.5	2.2
FSCQ0765RT	85	5	1.6
FSCQ0965RT	110	6	1.2
FSCQ1265RT	140	7	0.9
FSCQ1465RT	160	8	0.8
FSCQ1565RT	170	8	0.7
FSCQ1565RP	210	11.5	0.7

Green FPS for quasi-resonant switching converter



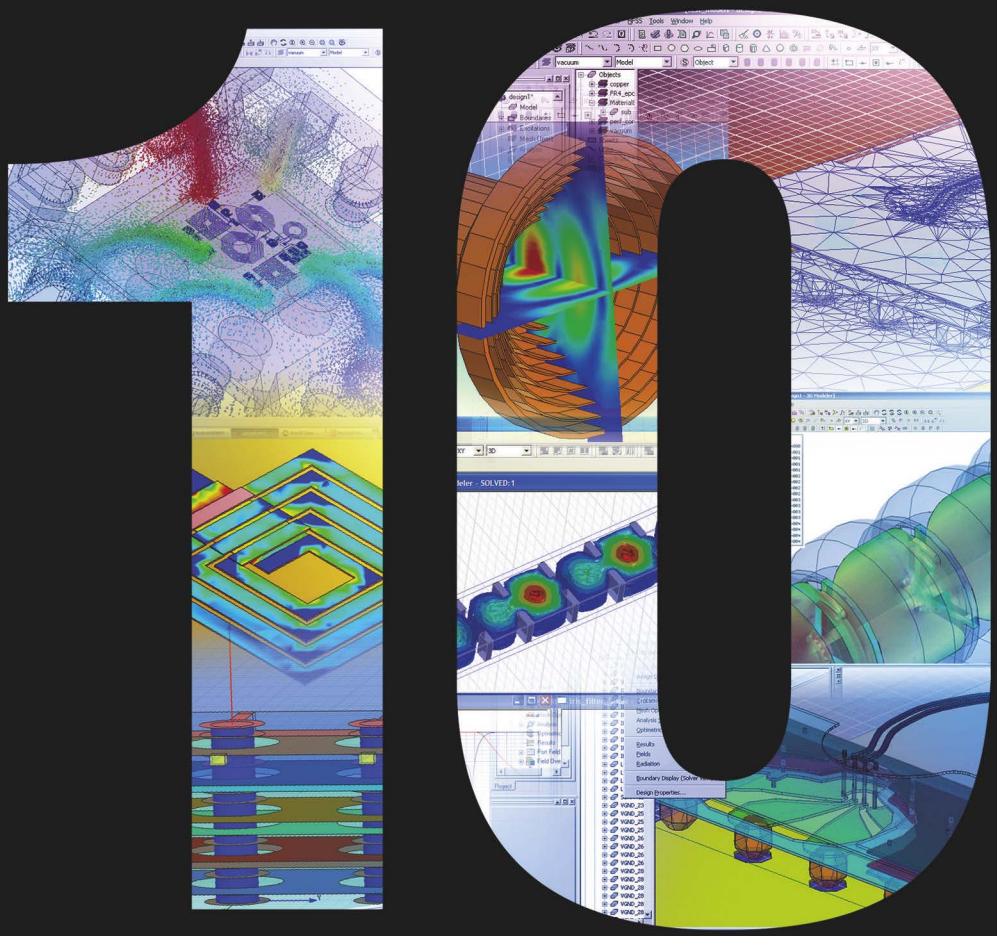
Only Fairchild offers complete SMPS solutions—including optically isolated error amps, PFC controllers, SuperFET™ MOSFETs, bridge rectifiers, diodes, online tools—even Global Power Resource Design Centers to accelerate your AC/DC designs.



For more information on our AC/DC solutions, design tools or to order an evaluation board, visit www.fairchildsemi.com/acdc/1.

www.fairchildsemi.com

the power franchise™



HFSS™ v10

THE POWER OF 10

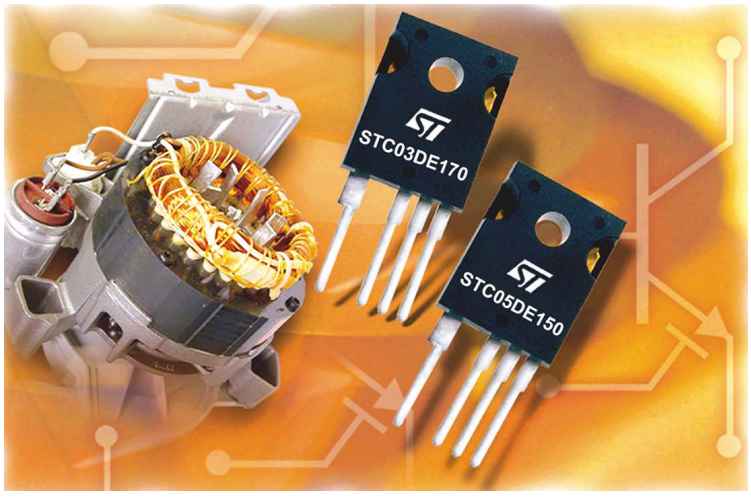
Experience the power of HFSS v10 and discover why it's the industry standard for high-performance electronic design. V10 powers high-frequency, high-speed design complexity and reduces design time with EM-circuit co-simulation for RF/Microwave, EMI/EMC, Optics, RF/Analog IC and multi-gigabit designs. V10 powers design-flow efficiency with robust CAD integration, geometric healing, model resolution and fault-tolerant meshing. V10 powers design optimization and engineering throughput with optional distributed analysis for parallel computing. Achieve the power of 10.

Visit hfss.com.

ANSOFT

productroundup

DISCRETE SEMICONDUCTORS



BJT/MOSFET hybrid retains benefits of each design

Targeting high-voltage, high-switching-frequency applications, this family of ESBTs (emitter-switched bipolar transistors) suits industrial three-phase auxiliary-power supplies and SEPICs (single-ended primary-inductance converters) for power-factor preregulators in industrial-lighting applications. The ESBT family incorporates a BJT (bipolar-junction transistor) and MOSFET connected in a cascade configuration in a single package. This feature enables the family to retain benefits including conduction losses comparable with those of a single BJT and the ability to achieve 130-kHz switching frequencies under hard, snubberless switching conditions. Additional features include a 1.7-kV, high-voltage capability, allowing designers to operate with a higher flyback voltage and a higher duty cycle which, in turn, allows the power supply to handle higher powers or to operate within a wider range of input voltage. The ESBT family includes the STC03DE150, STC03DE170, and STC08DE150 and costs $3.10, $3.30, and $3.60 (100), respectively.

STMicroelectronics, www.st.com

DirectFET MOSFETs reduce 200W-converter power loss

The 80V IRF6668 and 100V IRF6662 DirectFET MOSFETs primary-side power switches provide high efficiency for powering isolated dc/dc-bus converters, ASICs, network-processing units, and FPGAs in advanced networking and communication systems. The 100V device has a 4% lower on-resistance and 30% better performance figure of merit for combined on-state resistance and gate charge than competing enhanced SO-8 devices at 36 to 75V input, 8V output, 200W, and 220 kHz. The IRF6668 and IRF6662 cost 99 cents each (10,000).

International Rectifier, www.irf.com

Wireless-LAN InGaP HBT power amplifier features 30-dB power gain

Pairing with the vendor's LX5511 amplifier, the LX5506M targets 802.11a/b/g applications, which include the 2.3- to 2.5-GHz bandwidth. This InGaP (indium-gallium-phosphide) HBT (heterojunction-bipolar-transistor) power amplifier provides a 30-dB power gain operating in the 5.25-GHz

MAKE YOUR NEXT PCB LAYOUT A MASTERPIECE



PADS® PCB Design Solutions

What Michelangelo did for the Sistine Chapel you can do for your layout when you use PADS complete PCB design solution. If you are striving for excellence for an easy to use, intuitive solution, PADS gives you the freedom and power to create, at an affordable price. To find out more, download the latest technical paper at www.mentor.com/rd/padspaper or call us at 800.547.3000.

Mentor Graphics®

Copyright 2005 Mentor Graphic Corporation. All Rights Reserved. Mentor Graphics is a registered trademark of Mentor Graphics Corporation. All other company and/or product names are the trademarks and/or registered trademarks of their respective owners.

band. Operating from a 3.3V supply, the amplifier features a 16-pin microlead package with a built-in heat sink and a 3×3×0.9-mm footprint. Targeting portable 802.11a wireless-LAN applications, including Cardbus, mini-PCI, and access-point products, the LX5506M costs 85 cents (10,000).

Microsemi Corp, www.microsemi.com

I/O expanders control power functions

The AAT4296 and AAT4298 I/O expanders manage six functions through a control wire, allowing designers to expand general-purpose-I/O resources in portable, battery-powered systems. Both devices facilitate voltage level-shifting, operating at a 1.8 to 5V input-voltage range, with a 1.4V ENABLE/SET voltage input level. They use 3-µA quiescent current. The AAT4296 features five push/pull outputs, and the AAT4298 has six. The AAT4296 comes in a 2×2.2-mm SC-70JW package and costs 85 cents (1000).

AnalogicTech, www.analogictech.com

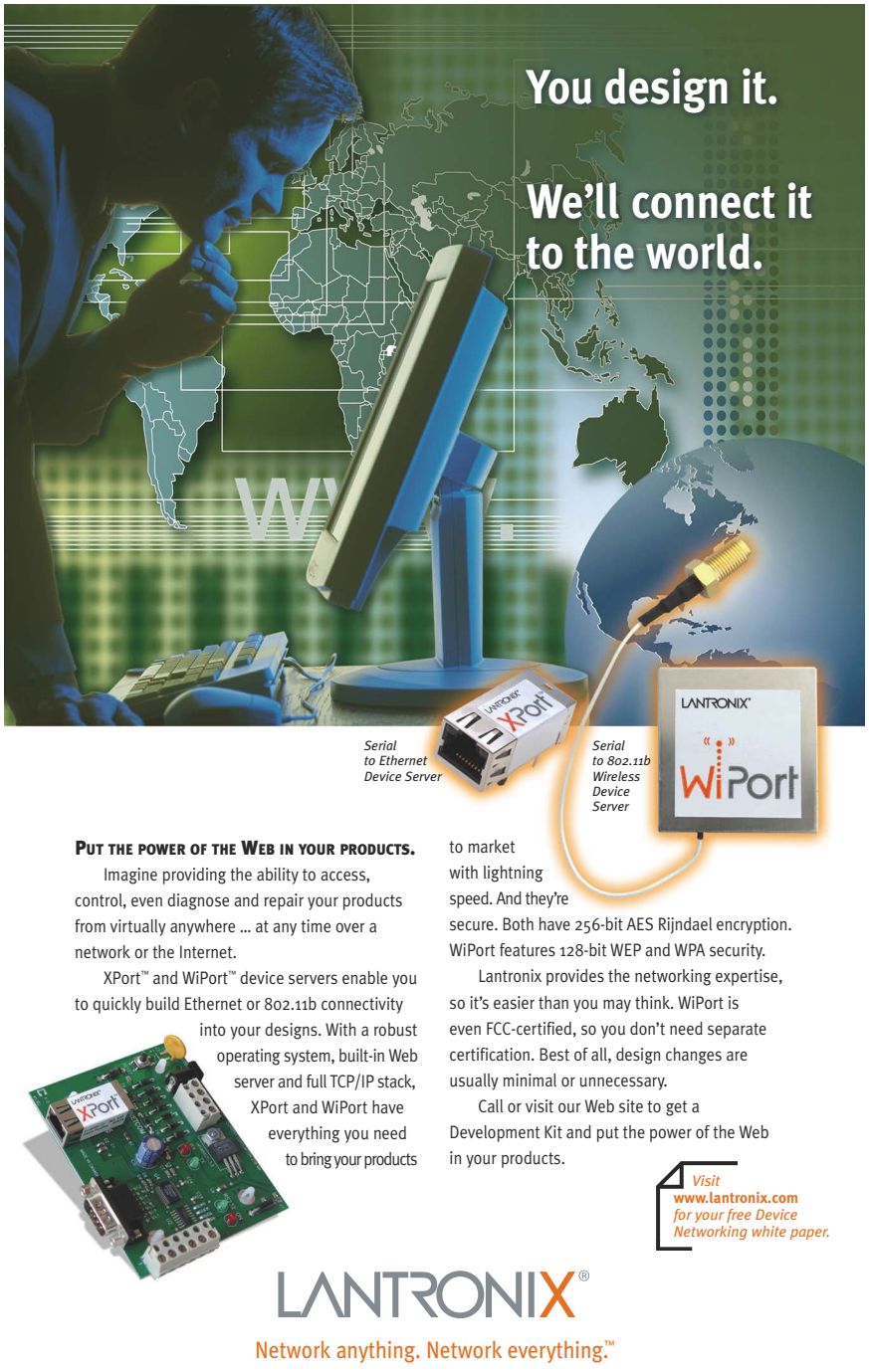
Low-saturation-voltage BJTs target portable and battery-powered systems

Aiming at applications in power management, battery charging, low-dropout regulation, vibrator motors, LED backlighting, disk-drive control, and camera flash, this BJT (bipolar-junction-transistor) family provides long battery life in cell phones, notebook computers, and digital cameras. By delivering a turn-on voltage of less than 1V, the devices can eliminate the typical charge pumps and enable the elimination of blocking diodes due to their bidirectional-current-blocking capability. The vendor claims a 10-cent-per-circuit cost savings by implementing the BJTs. The series costs 7 to 16 cents (10,000) and comes in SOT-23, SC-88, SC-74, TSOP-6, and ChipFET packages.

On Semiconductor, www.onsemi.com

Half-bridge MOSFET-driver ICs have flexible gate-drive levels

Siliconix 1.8V half-bridge N-channel-MOSFET drivers provide flexible gate-drive levels, reduce component count, and minimize expense in high-frequency, high-current, dc/dc, synchronous-rectifier buck power supplies. The SiP41108, SiP41109, and SiP41110 drivers operate with external N-channel MOSFETs. They provide 8 or 12V gate-drive voltages, operate at a 1-MHz switching frequency, and function in 5 to 48V systems, including power converters and industrial and computer equipment. A high-side driver has an internal bootstrap diode to reduce external component count. The SiP41109 and SiP41110 cost 85 cents each, and the



productroundup

DISCRETE SEMICONDUCTORS

SiP41108 costs 90 cents each.
Vishay Intertechnology, www.vishay.com

Innovative ESD-protection device has an ultrasmall design

Replacing four discrete devices including multiplayer varistors, the μClamp3324P reduces the necessary space for ESD (electrostatic-discharge) protection by 77% compared with competing devices. The vendor constructed the low-voltage, four-line ESD using a EPD TVS (enhanced-punch-through-diode transient-voltage suppressor) process technology, yielding 3.3V operating devices. The μClamp3324P comes in a 2.1×1.6×0.58-mm package and costs 41 cents (1000).
Semtech Corp, www.semtech.com

INTEGRATED CIRCUITS

CMOS image sensors feature low dark current and low noise

The vendors manufacture the CYIHDSC9000AA color and CYIHDSM9000AA monochrome 9 million-pixel CMOS image sensors in the 0.13-micron CMOS process, providing a 3710×2434 maximum resolution. The devices provide low dark current and low noise. Other features include a 6.4-micron pixel pitch, a 23.3×15.5-mm^2 array format with a 28-mm diagonal dimension, a 1.5 effective-focal-length multiplier, and a 3-to-2 aspect ratio. The devices achieve full resolution at five frames/sec and VGA resolution at 20 frames/sec. The CMOS image sensors cost $90.
Cypress Semiconductor Corp, www.cypress.com

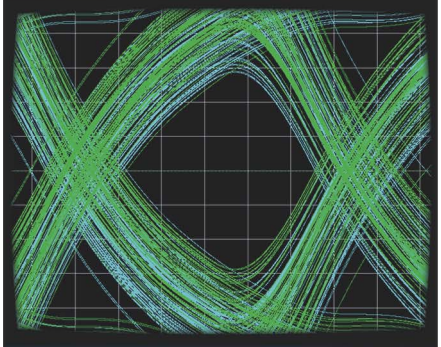
Class-KB audio power amplifier targets car-audio applications

Based on BiCMOS and double-diffused-MOS technology, the TB2905HQ Class-KB audio power amplifier suits car-audio needs, such as CD, DVD, and navigation applications. Features include four BTL (bridge-tied-load) amplifier channels, standby switching, offset and clipping detection, and protective circuits. Peripherals include JEITA 47W maximum power for four BTL amplifier channels at 4Ω and 14.4V, high performance at 2Ω with a 55W typical power for four BTL amplifier channels at 14.4V and 10% THD, and a 9 to 18V operating voltage. The TB2905HQ costs $5 (10,000).
Toshiba America Electronic Components Inc, www.toshiba.com/taec/

Active-pixel design provides major noise reduction

A 3.3-micron active-pixel design provides the ADCC-3960 EP 1.3 million-pixel CMOS image sensor with 10 times less noise than competing devices. With a one-third optical format, the sensor can process 15 frames/sec at full SXGA resolution and 30 frames/sec in VGA mode. The device contains 1280×1024 active pixels and incorporates a 10-bit A/D converter. Additional features include a programmable dual LED and Xenon flash-strobe synchronization, 4× digital zoom, antivignetting, picture sharpening and adaptive tone mapping, and automatic flicker correction. The ADCC-3960 costs $5 (1 million).
Agilent Technologies Inc, www.agilent.com

DON'T BLINK



HyperLynx®
Compatible with PADS® and all major PCB flows

If faster edge rates and new bus technologies are part of your next design, you need the right tools and they need to be easy to use. HyperLynx is the industry leading high-speed solution that allows you to make pre-route design tradeoffs, including trace topologies, buffer technologies, termination tradeoffs, as well as crosstalk, EMC, power, and cost tradeoffs – all before routing a single net. To find out more, download the latest hands-on high-speed tutorial from www.mentor.com/rd/hxdemo or call us at 800.547.3000.

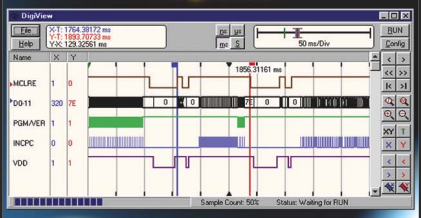
Mentor Graphics®

Copyright 2005 Mentor Graphic Corporation. All Rights Reserved.
Mentor Graphics is a registered trademark of Mentor Graphics Corporation.
All other company and/or product names are the trademarks and/or registered trademarks of their respective owners.

EDN productmart

This advertising is for new and current products.

Portable Logic Analyzer
uses real-time Hardware Compression



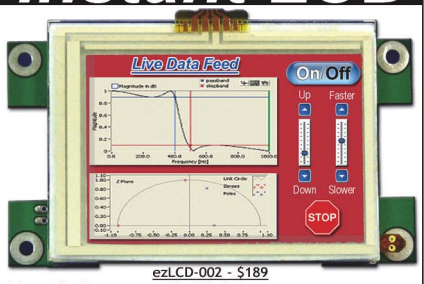
DigiView

See Our Other Embedded Development Tools!

100 MHz
18 Channels
only $499.00

Call: 972-272-9392 sales@tech-tools.com
www.tech-tools.com

Instant LCD



ezLCD-002 - $189

- Versatile Programmable Module
- Serial/I²C/USB/Parallel Interface
- AVR/BASIC Stamp/VB Compatible
- Onboard Flash Bitmap Memory
- Downloadable TTF Fonts
- 2.7" or 5.6" TOUCH Color TFT LCD
- 240x160 or 320x240 resolutions
- Transflective w/ LED Frontlight (2.7")
- Transmissive w/ 350 nit backlight (5.6")
- 512 colors or 65,535 colors

EARTHLCD.COM We Make LCDs Work.™

USB CANbus I2C RS232/485 GPS

I2C & USB BUS ANALYZERS

DATA-LOGGING & PC SCOPES

USB to I²C for PC's



NEW! UCA93LV - *bus-powered* **USB I2C** interface - great for laptops! 400kHz bus monitoring / addr. filtering! Also: **PCI93LV - PCIbus version** I2C master/slave/bus-monitor. **$499.00**



USB in one IC!

FT232R - NEW! USB1.1 serial IC with new "security-dongle" features. Each IC has unique ID! Internal EEPROM, clockgen, pullups, etc. Smaller/cheaper than FT232BM **$2.15 (1000)**

Saelig Company Inc.
p: 888-7-SAELIG
www.saelig.com

MADELL TECHNOLOGY

www.madelltech.com
Phone: (877) 670-9023
(402) 319-4101
E-mail: info@madelltech.com



CA1640-20
20MHz Sweeping Function Generator
$260



QK857D Hot Air Rework Station
Soft and rotating hot air
Suitable for high density circuit boards
Automatic On/Off switch $185

QK702ESD 3-in-1 Rework Station



Hot air gun, soldering iron and desoldering gun, a complete work system.
$449



AS-5001 Mini Automatic Reflow Oven
Light weight, working area 7"x4.5", temperature to 250°C, reflow or preheat modes $798



BGA Repair Systems
Advanced BGA repair systems with split vision assisted alignment and precision placement.

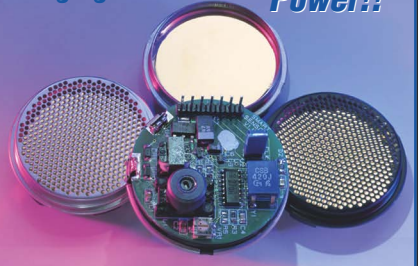


Tabletop Automatic Pick & Place Machine
Least expensive automatic pick and place machine on the market. Just dropped price.

Free tools with purchases

Test and measurement, SMT Equipment, Rework Stations, Lab Equipment, Bio-laboratory, Optics and more

Complete Ultrasonic Ranging Sensor – Just Add Power!!



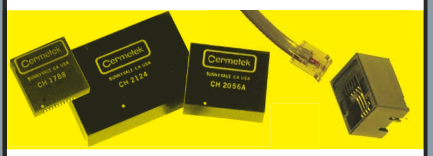
- Same Sensor Invented by Polaroid to Focus Cameras!
- Electrostatic Transducer and Drive Module in One Complete Package!
- Non-Contact Ranging and Measurement from 6" to over 40'!
- Perfect Sensor for Non-Contact Measurements, Liquid or Bulk Level Sensing, Proximity Sensing, Robot Guidance
- We Sell Complete Ranging Kits and Components

SensComp

Phone 734-953-4783
Fax 734-953-4518
www.senscomp.com

To advertise in Product Mart, call Judy Keseberg at 800-417-5370

Modems Plus



Modems and Internet Modems

- Speeds from 2400 to 56k bps
- Optional SMTP, TCP/IP Enabled
- Caller ID, DTMF signaling
- Off hook detection, Priority pick up
- Approved; FCC. UL, CSA, CS-03
- Evaluation kits
- Low cost starting at $19.95

www.cermetek.com

Tel: 800-882-6271
Sunnyvale, CA USA

Cermetek microelectronics

C-Eye™ Standalone Vision System

OEM $79



Features:
640x480 Image Sensor, Color/BW, 4x3", C/C++ Programmable x86, CompactFlash FAT, Ethernet TCP/IP, RS232/485, RTC, TTL

Application:
Machine vision; ID mark check; Pattern recognition; Industrial process control; Motion position detection; Security monitoring; image acquisition and recording.

50+ Low Cost Controllers with ADC, DAC, solenoid drivers, relays, file system with CompactFlash, LCD, DSP motion control, 18 UARTs, 300 I/Os. Custom board design. Save time and money.

TERN INC.
1724 Picasso Ave., Suite A
Davis, CA 95616 USA
Tel: 530-758-0180 • Fax: 530-758-0181
www.tern.com
sales@tern.com

China Connection...

PCB Production,
Assembly,
Turnkey

Prototype ~ Production

D/S PCB ~ 12¢ per in^2
4-L PCB ~ 20¢ per in^2

10 days Delivery w/solder Mask
NRE not included
UL Approved

MYLYDIA INC.
1-800-Mylydia
sales@mylydia.com
www.mylydia.com

EDN ADVERTISER INDEX

Company	Page
Agilent Technologies	15
Alps Electric Co Ltd	25
Altera Corp	31
Analog Devices Inc	4-5
Ansoft Corp	88
Arcom Control Systems Ltd	50
Bergquist Co	2
Cermetek	93
Cirrus Logic Inc	65
Digi-Key Corp	1
Earthlcd	92
Echelon Corp	59
Fairchild Semiconductor	66, 87
Freescale Semiconductor	33, 35
FTDI Ltd	26
International Rectifier Corp	39
Intersil	3, 37
	63, 85
Lantronix	90
Linear Technology Corp	73
	75, 76
	77-78
Madell Corp	92
Magma Design Automation	6
Mathworks Inc	40
Maxim Integrated Products	81
	83
Mentor Graphics	89
	91, 93
Micrel Semiconductor	43
Microchip Technology	69
Microsoft Corp	12,13
Molex Inc	47
Monolithic Power Systems	60
Mouser Electronics	C-3
Mylydia Inc	93
National Instruments	55
	67
National Semiconductor	10
	17-24
	45
NCI	16
Performance Motion Devices	68
Saelig Co Inc	92
Senscomp Inc	92
STMicroelectronics	C-4
Tech Tools	92
Tektronix	49
Tern	93
Texas Instruments	C-2
	57
	8
	40-A
	40-B
That Corp	16
Vicor Corp	70
WinSystems	29
Xilinx Inc	51

This index is provided as an additional service. The publisher does not assume any liability for errors or omissions. For immediate information on products and services, go to Reader Service under Tools & Service at www.edn.com.

PADS
IT'S EVERYWHERE



PADS® and HyperLynx®
Available through Value Added Resellers

PADS resellers are full-service companies that provide sales, tech support and customized services in your region. These resellers are our partners; they understand your needs and can help you grow your business. PADS resellers provide solutions that will improve the quality of your designs on time and within budget. Visit www.mentor.com/rd/buypads or call us at 800.547.3000 to find your local reseller.

Mentor Graphics®

Copyright 2005 Mentor Graphic Corporation. All Rights Reserved.
Mentor Graphics is a registered trademark of Mentor Graphics Corporation.
All other company and/or product names are the trademarks and/or registered trademarks of their respective owners.

realitycheck

YESTERDAY'S HYPE MEETS TODAY'S REALITY



STATS Volume at end of life: 100 units/month / Music capacity: 90 minutes to three hours

DAT stirs piracy fears, loses out to plastic discs

In the mid-1980s, DAT (digital-audio tape) was poised to become a mainstream music medium. Sampling modes varied from 12 bits at 32 kHz to 24 bits at 96 kHz, resulting in storage capacities of 90 minutes to three hours. But DAT's real claim to fame was lossless recoding. DAT would allow perfect duplication of digital content, such as audio CDs. Of course, the recording industry was no more enlightened back then than it is today and quickly lobbied for mitigation. The result was the Home Recording Act of 1992—also called the DAT tax. The act levied a royalty on all DAT recorders and media and mandated the Serial Copy Management System that limited DAT recorders to a single perfect copy.

It turns out that affordable, recordable CD technology was just around the corner. Thus, DAT's success was limited to studio and audiophile customers. In November, Sony announced that it would discontinue its DAT product, as demand had dropped to approximately 100 units/month. As of mid-December, the outlet section of the Sony Electronics Web site offered the DTC-ZE700 for $500—$300 less than retail.

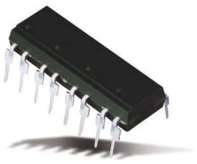


OMRON OPTICAL NETWORK DEVICES

Omron's new P1L Multimode Micro Lens Arrays, P1X CWDM Mux/Demux, and P1S Optical Switches turn recent theory into real solutions for tomorrow's high-speed, free-space fiber/data communication links.

OMRON ELECTRONIC COMPONENTS *mouser.com/omron/a*

SHARP PHOTOCOUPLERS



These VDE certified products are for general applications such as telecommunication devices, white goods, and PLCs. Sharp is an industry leader in Optocomponents.

SHARP MICROELECTRONICS OF THE AMERICAS *mouser.com/sharpsma/a*

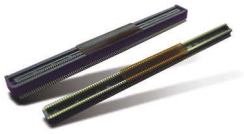
AMPHENOL RADSOK® POWER BUS CONNECTORS



RADSOK® technology provides higher power in a smaller package. Features include higher ampacity, lower insertion force, high cycle durability, and high reliability.

Amphenol® *mouser.com/amphenol/a*

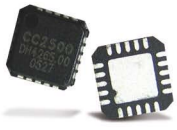
JAE MICRO DIMM CONNECTOR



This WA6 Series is the new DDR2 MicroDimm standard. The WA6 is a memory module for many consumer products. The current rating is 0.3 A.

JAE *mouser.com/jae/a*

CHIPCON CC1100 & CC2500 RF TRANSCEIVERS



The CC1100 UHF RF transceiver and the CC2500 2.4GHz RF transceiver are built upon the advanced 0.18 µm CMOS technology offering superior RF performance, the market's lowest system cost, and very low-power consumption in tiny 4 x 4 mm, 20-pin QLP packages.

Chipcon *mouser.com/chipcon/a*



LAMINA BL-4000 LED LIGHT ENGINES

Lamina's newest LED light source delivers 120 lumens of blended RGB and 120 lumens in white (5500°K) from a single point. Designed for decorative effects using color, the RGB is the brightest and smallest RGB LED Light source available, and is designed for optimal color mixing.

lamina *mouser.com/lamina/a*

THE MOUSER ADVANTAGE:

FASTER TIME TO MARKET



For over 40 years engineers have relied on Mouser as their source for electronic components. And with the quickest market introduction of new products, Mouser also gives you a critical time-to-market advantage.

That's why we deliver a 1,600+ page catalog of the newest product information 4 times a year. And with daily updates to over half a million products on-line, you can depend on Mouser to save you critical time to market!

Experience Mouser's time-to-market advantage! Our vast selection of the NEWEST products, no minimums, and same-day shipping on most orders, gets you to market faster. We make it easy to do business with Mouser.

mouser.com **(800) 346-6873**

MOUSER ELECTRONICS
a tti company

NEW Products
NEW Technologies
NEW Suppliers

The NEWEST Semiconductors | Passives | Interconnects | Power | Electromechanical | Test, Tools & Supplies

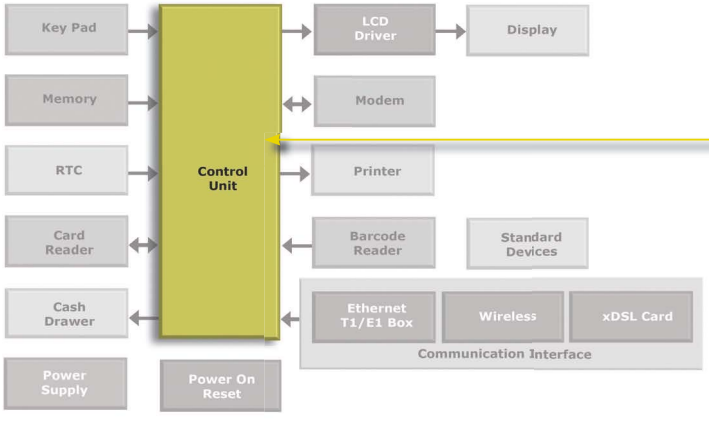
Mouser and Mouser Electronics are registered trademarks of Mouser Electronics, Inc. Any other product and company names mentioned herein are trademarks of their respective owners.

Industrial Applications

Solutions

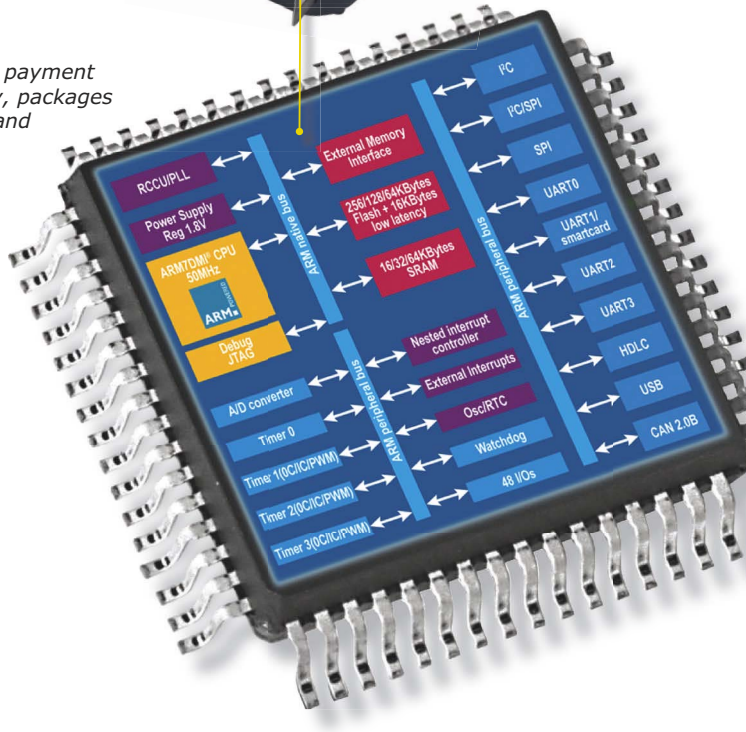
STR7 ARM™-based 32-bit Flash MCU with USB and CAN gives you control over power and performance and brings innovation to your design.

Innovative products for multi-segment application systems





With STR7 ARM7TDMI MCU, designing versatile products like card payment terminals is easy.The STR7 family offers a large choice of memory, packages and peripherals. Extensive application support (application notes and software libraries including USB) makes design even easier.



Key Benefits

- Future-proof 32-bit ARM-based microcontrollers
- Largest choice of peripherals and interfaces, including USB and CAN
- Flexible power and clock management with two independently clocked APB peripheral buses
- High-quality embedded Flash (20 years retention)
- Extensive software and easy-to-use evaluation kits

Key Applications

- POS: secure card reader, receipt printer, bill validation
- USB devices: security token, card reader
- Industrial: factory automation, circuit breaker, industrial network, PLC
- HVAC and Building: fire, access and security, alarm system, power meter
- Medical: patient monitoring, diagnostic systems
- Appliances: washer and dryer, dishwasher
- Others: hands-free car kit, electric wheelchair, cellular phone base station

For full documentation, developer kits, software and user forums, visit www.st.com/str7-arm

All brand names and product names are the property of their respective holders.

Solutions @

DEVICE AVAILABLE FROM THESE DISTRIBUTORS: ARROW • AVNET • DIGI-KEY • FUTURE • MOUSER • NU-HORIZONS